HANDLING FROZEN FOODS FROM WAREHOUSE RECEIVING TO RETAIL DISPLAY: AN EVALUATION OF SELECTED METHODS AND SYSTEMS

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PREFACE

This study of frozen food handling in warehouses and retail stores is part of a broad program aimed at reducing the cost of marketing farm products. One phase of this research is the development of methods for increasing the efficiency of food wholesaling and retailing.

Increased efficiency results in better service or lower marketing costs and savings which are reflected in lower consumer prices, increased producer returns, or both.

Management of Angelo's Supermarkets, Holbrook, Mass.; DeMoulas Supermarkets, Chelmsford, Mass.; First National Stores, Somerville, Mass.; S. M. Flickinger, Buffalo, N.Y.; Hendries R.C.S., Southboro, Mass.; Iandoli Supermarkets, Worchester, Mass.; Penn Fruit Company, Philadelphia, Pa.; and Roche Brothers Supermarkets, Dedham, Mass., deserve special acknowledgment for providing facilities and data used in this study.

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HANDLING FROZEN FOODS FROM WAREHOUSE RECEIVING TO RETAIL DISPLAY: AN EVALUATION OF SELECTED METHODS AND SYSTEMS

By Jack L. Runyan, Richard H. Silverman, and Errol R. Bragg[1]

SUMMARY

Studies were conducted of three methods for handling frozen food from warehouse receiving to selection, nine methods for selecting retail frozen food orders, four methods for loading frozen foods into delivery vehicles, three methods for transporting frozen foods from warehouse to retail stores, four methods for unloading frozen foods at retail stores, three methods of transferring frozen foods from retail receiving to the sales area, four methods for price marking frozen food, and stocking three types of retail display cases. In addition to studying various methods for handling frozen foods from warehouse receiving to retail store display, nine systems (composed of the methods studied) for handling frozen foods were also studied. Finally, the impact of ceiling height on construction and rental costs of frozen food warehouses was measured.

In order to develop meaningful cost comparisons, common denominators were developed for labor, equipment, and facility costs. Therefore, users of the study results should incorporate their own costs.

For warehouse receiving, the storage-retrieval machine method required less labor time (0.053 man-minute per case) than did the powered pallet jack-forklift method (0.064 man-minute per case) and the forklift truck method (0.058 man-minute per case). However, the forklift truck method had lower costs (2.642 cents per case compared with 2.733 cents per case for the powered pallet jack-forklift truck method and 4.526 cents for the storage-retrieval machine method).

For replenishing the warehouse selection area, the storage-retrieval machine method also had the lowest labor requirements (0.068 man-minute per case) and the highest cost (6.046 cents per case). The forklift truck method required 0.091 man-minute per case and had the lowest cost (3.540 cents per case). The powered pallet jack-forklift truck method required 0.097 man-minute per case and cost 3.631 cents per case.

For selecting orders and loading them on delivery vehicles, labor requirements and total costs ranged from a low of 0.291 man-minute and 4.336 cents per case for the conveyor-manual sorting-cart method to a high of 0.689 man-minute and 14.443 cents per case for the insulated carts and tuggers method.

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[1]Marketing specialist, Food Distribution Research Laboratory, Beltsville, Md.; president, Richard H. Silverman and Associates, Weston, Mass.; and marketing specialist, Food Distribution Research Laboratory, Beltsville, Md.

When frozen products are delivered with nonfrozen products in an unrefrigerated truck using insulated shrouds, the labor and equipment costs for the shrouds amount to 1.30 cents per case. Movable bulkheads cost 1.54 cents per case shipped and are used when frozen products are shipped with nonfrozen products in a refrigerated truck.

Hand-stacked loads cost 1.115 cents per case less than pallet loads and 2.341 cents per case less than cartloads to transport from warehouse to retail store when only frozen products are being transported.

When unitized loads (pallet loads, cartloads, and container loads) are unloaded at retail stores, the dock method has lower labor requirements (range = 0.076-0.216 man-minute per case) and total costs (range = 0.862-2.341 cents per case) than either the store lift method (range = 0.108-0.272 man-minute per case and 2.721-4.488 cents per case) or the truck lift method (range = 0.092-0.244 man-minute per case and 1.339-2.956 cents per case).

For transferring products from retail store receiving to the sales area, sorting from units onto stock carts had lower labor requirements (range = 0.145-0.154 man-minute per case) and total costs (1.593-1.688 cents per case) than sorting directly from the unit onto the sales floor (range = 0.253-0.300 man-minute per case and 2.661-3.150 cents per case) or stocking directly from the unit (range = 0.173-0.184 man-minute per case and 1.817-1.932 cents per case).

The stick stamp price marking method had equal or lower labor requirements (0.844 man-minute per case) and lower costs (9.125 cents per case) than the self-inking stick stamp method (0.844 man-minute and 9.166 cents per case), the label method (0.892 man-minute and 9.708 cents per case), and the band-stamp method (0.993 man-minute and 10.603 cents per case). The important key to successful price marking is to keep the product surface frozen.

Single deck or "coffin" type display cases had lower labor requirements (0.606 man-minute per case) and costs (6.363 cents per case) for stocking than the multilevel upright display case (0.712 man-minute and 7.476 cents per case) and the reach-in display case (0.685 man-minute and 7.193 cents per case).

When only handling costs and requirements were considered, the following system had the lowest cost (30.774 cents per case): (1) Forklift trucks for handling products during warehouse receiving and replenishing; (2) selecting single store orders onto conveyors; (3) handstack store orders into delivery vehicles; (4) use conveyors for unloading at retail stores; (5) sort products onto stock carts for transferring to the sales area; (6) price mark with stick stamps; and (7) stock single deck display cases.

When insulated shrouds rather than totally refrigerated trucks are used to protect the product during delivery or when warehouse facility rental costs are added to handling costs, the lowest cost system is as follows: (1) Forklift trucks for warehouse receiving and replenishing; (2) batch selection of store orders onto conveyors with manual sorting of orders onto carts; (3) unloading at retail stores with docks, store lifts, or truck lifts; (4) sorting products onto stock carts for transfer to the sales area; (5) price marking with stick stamps; and (6) stocking single deck display cases (26.605 cents per case when

insulated shrouds are used and 37.781 cents per case when facility rental costs are included).

Increasing ceiling heights of warehouses where the studies were done to the maximum operating height of the equipment used could reduce annual facility rental by as much as 2.068 cents per case (range = 0.276-2.068 cents per case).

INTRODUCTION

Frozen food sales account for approximately 4 percent of supermarket sales.[2] Although frozen foods do not account for the majority of supermarket sales, they require special handling methods and equipment at the warehouse, during transportation, and at the supermarket because the product is frozen and must remain frozen.

At the warehouse the product is stored in temperatures ranging from -10° to -20°F. The cost of constructing and equipping a facility to store frozen food amounts to about $35 to $40 per square foot compared with about $15 to $20 per square foot for constructing a dry grocery warehouse. Employees working in frozen food warehouses typically are paid higher wages than employees working in dry grocery warehouses ($7.00 per hour vs. $6.70)[3] and have lower productivity (175 cases of frozen food selected per man-hour vs. 202 cases of groceries, when order selectors in both operations used double pallet jacks and two pallets).[4] Higher wages are paid to employees in frozen food warehouses than in dry grocery warehouses in order to attract employees to an uncomfortable working environment. Lower productivity of employees in frozen food warehouses compared with employees in dry grocery warehouses is caused by frozen food order sizes being small and therefore requiring more time per case to fill, frozen food warehouse employees having more restricted mobility due to heavier clothing, and frozen food warehouse employees leaving the working area more frequently to get warm.

Equipment used to transport frozen food from warehouses to retail stores is more expensive than equipment used to transport dry groceries ($22,000 for a 40-foot refrigerated trailer vs. $8,000 for a dry freight trailer).[5] In addition to the higher initial cost of the delivery equipment, the refrigerating equipment must be operated and maintained, thus causing higher operating costs than those for dry freight delivery equipment.

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[2]Progressive Grocer. 36 pp. New York, Butterick Division, American Can Company, April 1975.

[3]Based on 1975 wage rate levels in the Washington, D.C., area.

[4]Based on result of this study and on Shaffer, Paul F., and Runyan, Jack L. Cost of handling groceries from warehouse to retail sales floor with warehouse pallets and mobile carts. USDA Agr. Res. Serv. ARS 52-69, 11 pp. 1972.

[5]Based on an average of prices quoted by trailer sales companies in the Washington, D.C., area, 1975.

Retail display cases for frozen food are more expensive than regular grocery display shelves. Costs per base linear foot of display were from $271 to $440 for frozen foods compared with $17 for groceries.[6]

In addition to the building, labor, and equipment costs discussed above, there are also operating costs. All of these costs combined make frozen food an expensive line to handle. Management has little control over these costs because all of the inputs are required for handling frozen food. Therefore, in order to hold down cost increases and maintain an acceptable profit level, management must constantly be seeking ways to improve productivity of buildings, labor, and equipment.

Objectives

The overall objective of this study was to evaluate the economic advantages and technical efficiencies of improved handling methods, equipment, and layouts used for handling frozen food (excluding frozen meat) in warehouses, delivery to retail stores, and in retail stores.

The specific objectives of this study were to:

1. Update costs appearing in two earlier U.S. Department of Agriculture studies of frozen food handling;[7]

2. Determine costs for handling frozen food using equipment and methods not included in the studies in the first specific objective;

3. Develop labor, equipment, and facility cost comparisons for the handling methods studied in specific objectives 1 and 2 above;

4. Determine the most efficient and least costly method for handling frozen food from warehouse receiving to retail store display; and

5. Determine the economics of high stacking of products in frozen food warehouses using the methods and equipment studied.

Approach

In order to accomplish the objectives of this study, the following approach was used.

First, a list of methods and equipment for handling frozen foods from the time they were received at the warehouse until they were displayed in the retail

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[6] American Frozen Food Institute. COSMOS. 64 pp. Washington, D.C. 1974.

[7] Anderson, Dale L., and Shaffer, Paul F. Improved handling of frozen foods in retail stores. U.S. Dept. Agr. Mktg. Res. Rpt. 104, 24 pp. 1955.
Lundquist, Arnold L. Improved handling methods and layout in affiliated frozen food warehouses. U.S. Dept. Agr. Mktg. Res. Rpt. 823, 33 pp. 1968.

stores was developed. This list was compiled from information received from equipment vendors, retailers, wholesalers, and others having knowledge of frozen food handling.

Second, from the list of handling methods and equipment compiled, methods and equipment for handling frozen food in 7 warehouses, 21 deliveries, and 21 retail stores were selected for detailed study.

Third, in each of these warehouses and retail stores, labor and equipment requirements for handling frozen food were obtained by conducting detailed time studies. In addition, costs for labor, equipment, facilities, materials and supplies, maintenance, power, and other factors were obtained at each firm where studies were conducted.

Fourth, in order to develop meaningful cost comparisons, common denominators were developed for labor, equipment, and facility costs. The use of common denominators is necessary because this is a study of methods and systems, and any regional cost differentials would introduce an external bias (nonmethod or nonsystem related) to the analysis. Persons using the study results should incorporate their labor, equipment, and facility costs because these costs do have large impacts for individual operations.

Fifth, to estimate the costs for various clear stacking heights in frozen food warehouses, facilities to house the highest possible operating height of the equipment, or necessary for handling inventory, or for order selection methods studied were simulated. From the simulations, rental costs for each high stacking facility were estimated.

Finally, cost comparisons were developed for the equipment, methods, and facilities evaluated and simulated.

A description of the methods and equipment evaluated in the study is contained in the next section of the report.

METHODS STUDIED

Each of the methods studied and the equipment required for each method (according to function performed) are described below. The description of methods will not include the current widely used procedures or methods. Any widely used procedure or method, such as picking slots numbered and arranged in a systematic pattern or order sheets that have been printed in warehouse selection slot sequence, were considered to be a normal part of the methods studied. Any unusual method or procedure being used ("floating slot" method) is described. The discussion of each method will also include related methods of operations.

Receiving

Warehouse receiving, as used for this study, includes unloading, transporting to reserve storage, and placing into reserve storage.

Unloading.--One unloading method studied involved placing plywood sheets on dollies, pushing the dollies into the truck (or railcar), placing products on the plywood sheets, and wheeling the loaded dollies onto the dock (fig. 1) The size of the plywood sheets was either 4 feet by 4 feet by 3/4 inch or 2 feet by 4 feet by 3/4 inch. When the 2- by 4-foot plywood sheets were used, two of them were placed on one dolly and a sheet of cardboard was placed over them before the cases were stacked. It should be noted that the plywood sheets require pallet racks without crossbars (such as drive-in or type used with storage-retrieval machines) because there is no place to insert the forks of the lift trucks except under the sheets. The loaded plywood sheets in the operation studied were transferred with a forklift from the receiving dock to a staging area for a manually operated storage-retrieval machine.

Figure 1.--Placing cases of frozen food onto plywood sheets and dolly during unloading at a frozen food warehouse.

The other unloading method studied involved placing an empty pallet in the truck (or railcar), loading the cases onto the pallet, and removing the loaded pallet from the vehicle with either a nonpowered pallet jack or a small forklift truck. In firms where nonpowered pallet jacks were used for removing loaded pallets from the delivery vehicle, forklift trucks would double-stack the pallet loads and transport them to reserve storage. In firms where small forklift trucks were used for removing loaded pallets from the delivery vehicle, the forklift truck operators would double-stack the pallet loads, and powered pallet jack operators would transport them to reserve storage.

Transporting to reserve storage.--At the firm where plywood sheets were used, forklift operators would remove the loaded sheets from the dollies and place them on a slightly declining roller conveyor (fig. 2). The loaded sheets rolled very slowly down the conveyor until they stopped at the point where the storage-retrieval machine would engage a load and place it in reserve storage (fig. 3).

Figure 2.--Placing loaded plywood sheets of frozen food on roller conveyor for transfer to storage-retrieval machine pickup station.

Figure 3.--Transfer car of a storage-retrieval machine in position to engage loaded plywood sheets of frozen food.

At the firms where forklift trucks were used to move pallet loads from receiving to reserve storage, the forklift operator would double-stack pallet loads and transport them to the storage area. The stacks of pallets were deposited in the storage area and individually placed in reserve storage.

At the firm where powered pallet jacks were used to move pallet loads from receiving to reserve storage, forklifts working on the dock were used to double-stack the pallet loads. A powered pallet jack operator engaged the pallet stacks, transferred them to the storage area, and deposited them in an aisle near the correct storage location. A forklift operator then placed the loaded pallets into reserve storage.

Placing in reserve storage.--In the firm where storage-retrieval machines were used, products were placed in and removed from storage by the machines. Special equipment required included storage-retrieval units, racks, and pickup stations.

In the other firms, forklifts were used to place products into and remove them from reserve storage (fig. 4). The forklifts placed pallet loads that were either staged in the aisles or moved directly from receiving into reserve storage. The only equipment required was forklift trucks.

Figure 4.--Forklift truck being used to place a pallet load of frozen food into a pallet rack.

In one firm where multilevel platform trucks were used for selecting orders, a substantial portion of the reserve storage was used for selection ("floating slot" system). Using a "floating slot" system virtually eliminates the need for reserve storage.

Replenishing Selection Slots

Storage-retrieval machines.--In the operation where products were placed into reserve storage with a storage-retrieval machine, the storage-retrieval machine was used to transfer products from reserve storage to selection slots. The products were then selected onto conveyors. Although any selection method could be used with a storage-retrieval machine, the conveyor selection method more readily exploits the economics of higher stacking and less floorspace achieved with storage-retrieval machines.

Forklift trucks.--In operations where products were placed into reserve storage with forklift trucks, the forklift trucks also moved pallet loads of products from reserve storage to selection slots. It should be noted that forklift trucks could be used to move products from reserve storage in operations where storage-retrieval machines were used to place products in reserve storage. The economics of the forklift-storage-retrieval combination appear to be questionable. Any of the order selection methods studied could be used when forklifts are used to replenish selection slots.

Shipping

Warehouse shipping, as used for this study, includes selecting orders and loading delivery vehicles.

Selecting orders.--For purposes of this study selecting orders refers to the order selectors obtaining their store orders and equipment (when necessary), selecting the items listed on their store orders, and positioning the loaded equipment (when necessary) in the shipment-staging area.

Nine methods used for selecting frozen food orders were evaluated. These methods provide a good representation of the "state-of-the-art" in frozen food order selecting in 1975.

One method used batch selection (selecting cases for more than one customer at a time), conveyor take-away from point of selection, and automatic order sorting. More specifically, this method may be described as follows: (1) Order selectors placed labels (containing computer-printed information) on cases as they are selected;[8] (2) after being labeled, the selected cases are placed onto a conveyor and transferred to the automatic sorter (fig. 5); and (3) the automatic sorter read the coded information on the label and diverted the cases to the proper predesignated delivery truck loading lane. The batch selection, conveyor take-away, and automatic sorting method could be used with either of the replenishment methods studied and any of the loading methods studied. This

[8]The code printed on the label is omnidirectional so precise placing of labels is not required.

Figure 5.--Order selector placing cases of frozen food onto conveyor.

method was used with the storage-retrieval machine replenishing method and the hand-stacking loading method in the warehouse where the study was conducted. The equipment required for this method of selecting orders includes a conveyor system, machine-readable labels, and an automatic sorter.

The second method used single store order selection and conveyor take-away from point of selection. This method for selecting orders can simply be described by saying that the order selector places the case on the conveyor for transfer to the truck-loading area (fig. 6). This method for selecting orders could be used with either of the replenishing methods or any of the loading methods studied. In the warehouse where the method was studied, the forklift truck replenishing method and the hand-stacking loading method were used. The equipment required for this method is a conveyor system.

The third method used batch selection, conveyor take-away from point of selection, and manual order sorting. A more specific description of this method for selecting orders is: (1) Selectors mark (or label) cases and place them on conveyors; (2) selected cases are transferred via conveyor to the sorting equipment (which was a carousel (fig. 7) in the operation studied); and (3) the cases are sorted into the proper store orders according to the mark (or label) and then dovetailed with the loading method (carts, in the operation

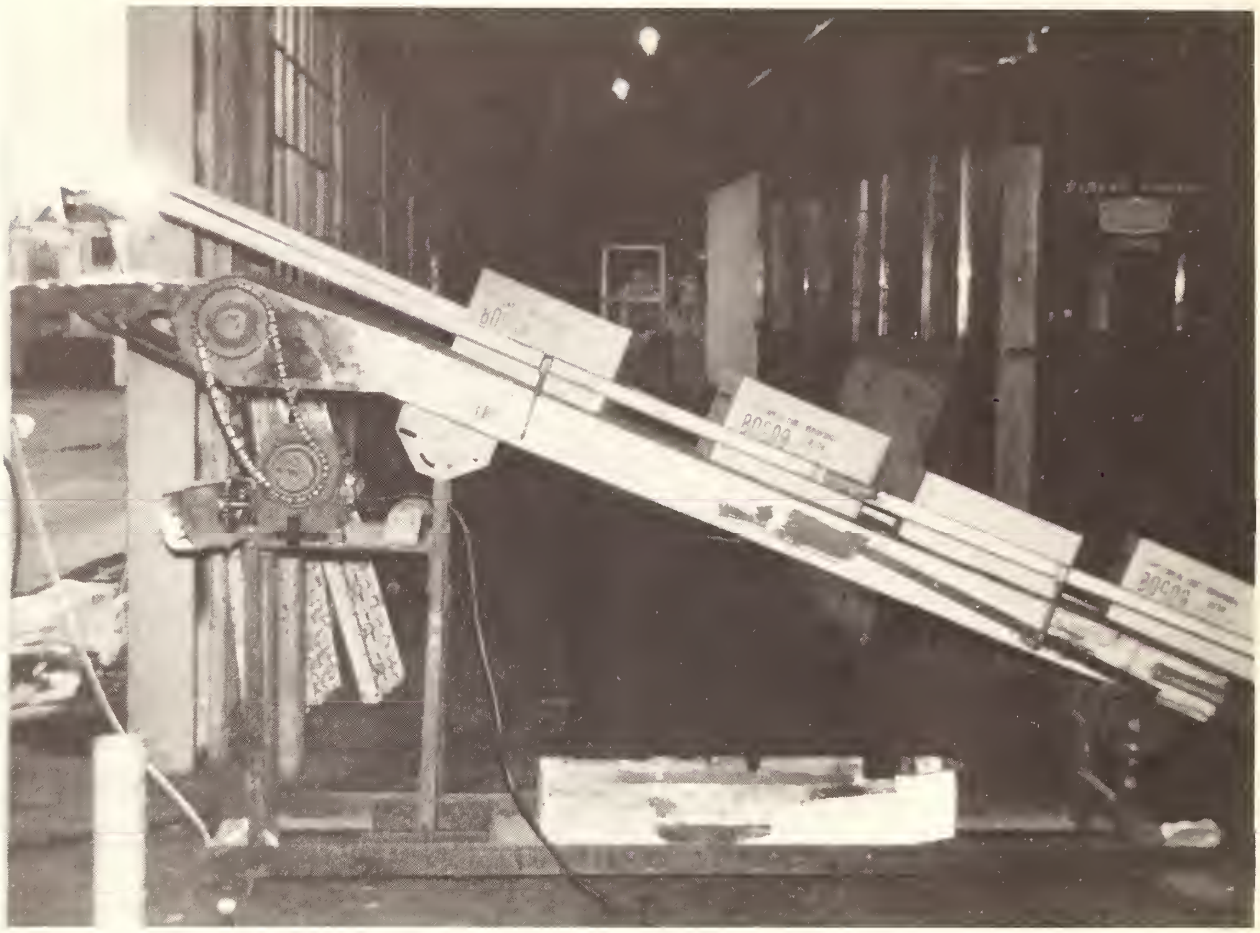

Figure 6.--Conveyor for loading cases of frozen food into delivery vehicles.

studied). Either of the replenishing methods or any of the loading methods studied (except that the hand-stacking method would require alterations) could be used with the third method for selecting orders. In the operation studied, this method was used with the forklift method of replenishing and cart method of loading. The equipment required for this method includes a conveyor system and sorting equipment.

The fourth method used single store order selection, and carts and tuggers to transport selected cases to the shipment staging area (fig. 8). A more specific description of this method for selecting orders is: (1) The order selector hitches one or a train of carts to a tugger; (2) selected cases are placed on a cart; and (3) when the carts are loaded or the order selected, the order selector returns to the shipping dock and parks the loaded carts in the shipment staging area. This method for selecting orders could be used with the

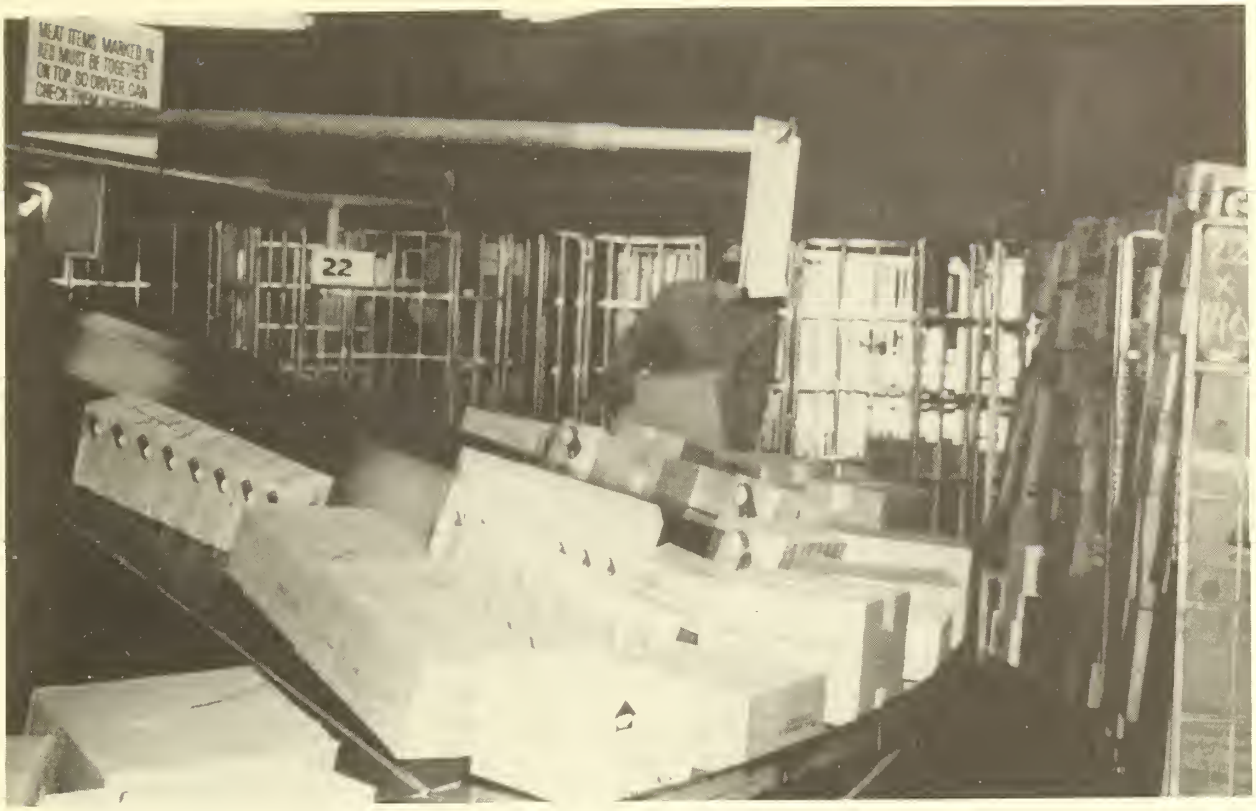

Figure 7.--Carousel used for sorting frozen food orders that were batch selected.

forklift truck method for replenishing[9] and the cart method of loading. The equipment required for this method of selecting orders includes carts (rigid or collapsible), hitches, and tuggers (including batteries and chargers).

The fifth method used single store order selection, pallets, and double pallet jacks to transport pallet loads to the shipment staging area (fig. 9). A more specific description of this method is: (1) The order selector engages two pallets with an electrically powered pallet jack; (2) selected cases are placed on the pallets; and (3) when the pallets are loaded or the order selected, the order selector returns the pallets to the shipment staging area. This method for selecting orders can be used with the forklift method of replenishing and the pallet or hand-stacking methods of loading. The equipment required for the pallet selection method includes pallets and powered double pallet jacks.

[9]Theoretically, the storage-retrieval method for replenishing could be used with this method for selecting orders. However, the forklift method would be easier to justify economically.

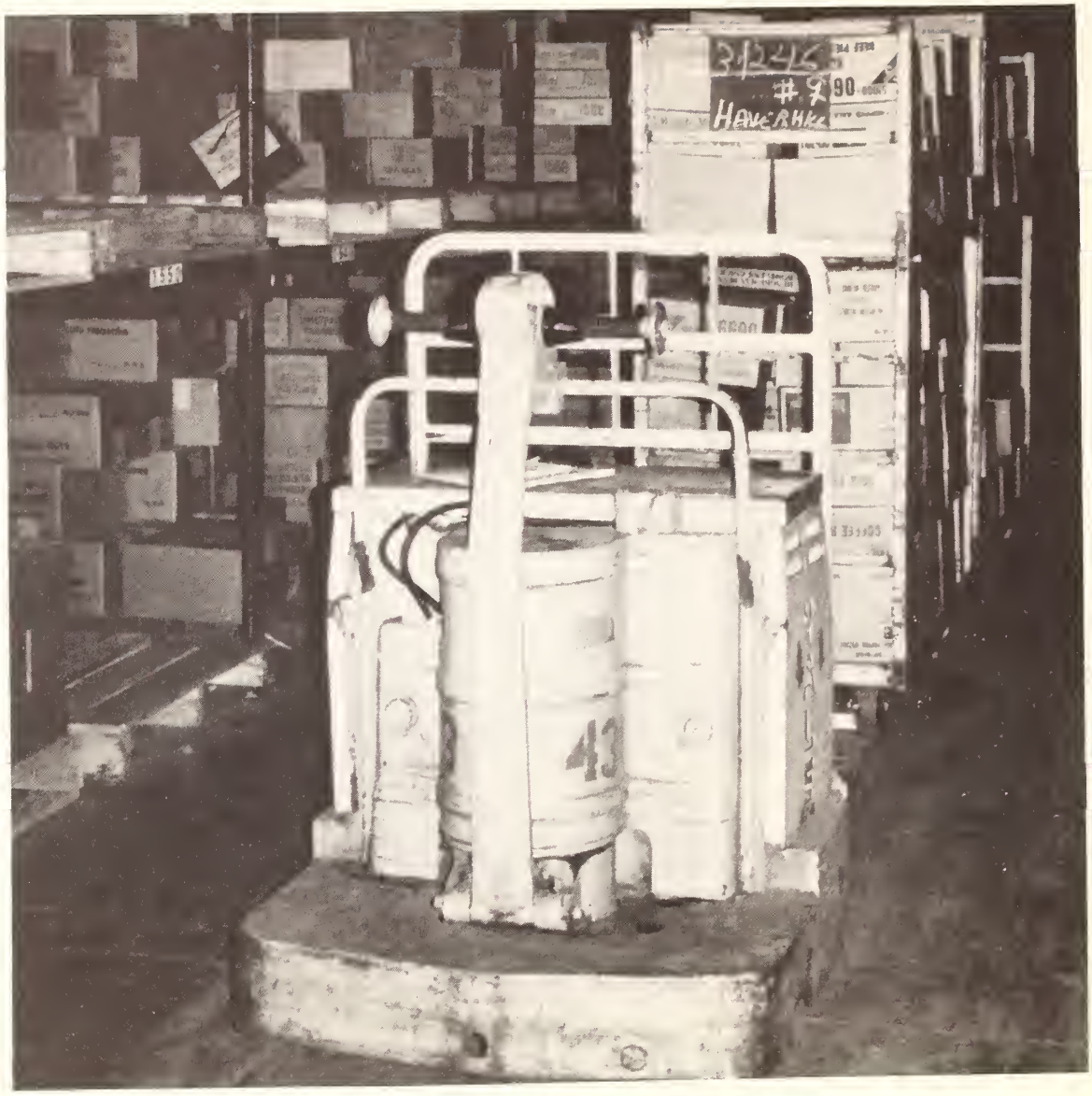

Figure 8.--Cart and tugger used for selecting frozen food orders.

The sixth method used single store order selection, pallets, and multilevel selecting machines (equipped with heaters) to transport order selectors and pallets during order selecting (fig. 10), and powered pallet jacks to transport loaded pallets from selection aisles to the shipment staging area. A more specific description of this method is: (1) The order selector engages a pallet with the multilevel selection machine; (2) selected cases are placed on the pallet; (3) when the pallet is loaded or the order selected, the pallet is placed in the aisle; and (4) loaded pallets are transported with powered pallet jacks to the shipment staging area. This method (which will be referred to as multilevel selection method) for selecting orders can be used with the forklift method of replenishing or used without any replenishing when a "floating slot" system is used. The cart, pallet, and hand-stacking loading

Figure 9.--Single pallet jack and pallet used for selecting frozen food orders.

method could also be used with the multilevel order selecting method. Obviously, a cart would have to be used in place of the pallet during selection before the cart loading method would be practical. The equipment for the multilevel selection method includes the selection machine equipped with heaters, electric power pickups, and other required accessories, pallets, and pallet jacks.

The seventh method used single store order selection, insulated carts, and tuggers to transport selected cases to the shipment staging area (fig. 11). This method for selecting orders may be more specifically described as follows: (1) The order selector hitches one or a train of insulated carts to a tugger;

Figure 10.--Multilevel order selecting machine used for frozen foods.

(2) cases are placed in the insulated carts (fig. 12); and (3) loaded carts are transferred to the shipment staging area. The insulated cart method for selecting orders could be used with replenishing by the fork truck method and loading by the insulated cart method. The equipment required for this method of selecting orders is insulated carts and tuggers.

The eighth method used single store order selection, insulated containers, and tuggers being moved on a predetermined guide path to transport selected cases. This method for selecting orders may be more specifically described as follows: (1) Dockman places nonpowered pallet jack (fig. 13) under containers to make them mobile; (2) order selector hitches a train of mobile insulated containers to a tugger; (3) train of insulated containers is moved to the guide path in the aisle (fig. 14); (4) selected cases are placed inside of the insulated containers; (5) a radio control device located on the order selector's belt is used to move the train along the guide path; and (6) the loaded containers are transferred from the selection area to the shipment staging area. This method for selecting orders can be used with two other methods: replenishing by the forklift and loading by insulated container. It should be noted that a predetermined guide path can be used with all methods using powered pallet jacks or tuggers and carts (insulated and noninsulated), and pallets. The equipment required for this selection method is insulated containers, nonpowered pallet jacks (to place under containers to make them mobile), powered tuggers with radio controls and guide path sensing devices, and guide path installation.

Figure 11.--Insulated cart and tugger used for selecting frozen food orders.

The ninth method used single store order selection, insulated containers, and powered single pallet jacks (fig. 15). A more specific description of this method is: (1) The order selector engages an empty container with a powered pallet jack; (2) selected cases are placed into the container; and (3) the loaded containers are placed in the shipment staging area. This method could be used with replenishing by the forklift method and loading by the insulated container method. The equipment required for this method of selecting orders includes insulated containers and powered single pallet jacks.

Loading delivery vehicles.--Loading delivery vehicles, as used for this study, refers to stripping the trailer of pallets, carts, containers, and other materials returned from the stores and positioning the selected cases in the delivery vehicle. Five methods used for loading delivery vehicles were studied.

Figure 12.--Inside view of a partially filled insulated cart used for selecting frozen food orders.

One method studied was the hand-stacking method. The description of the hand-stacking method of loading delivery vehicles is simply that a loader(s) hand-stacks cases in the delivery vehicle. This method of loading delivery vehicles can be used with any of the conveyor methods (fig. 16) of selecting orders or with the pallet method of selecting orders. The hand-stacking method can also be used with total refrigerated or variable refrigerated vehicle transporting methods and the conveyor unloading method. The equipment required for this method of loading delivery vehicles is an extension of the conveyor (when cases are selected onto conveyors) so cases can be moved into the vehicle, and some means to separate orders in the truck ("fish net" separators) if this was not done during selection (case labels or crayon markings). The hand-stacking method is used when it is necessary to maximize the load factors on the truck (for very long delivery runs).

The second method studied was the cart-loading method (fig. 17). Loading with the cart method required two operations: (1) Manually rolling the carts into position in the delivery vehicle; and (2) securing the carts in place with load-locking bars. This loading method can be used with the conveyor methods of selecting orders (batch select with manual sort was the conveyor method studied with cart loading), the multilevel selection method, and the carts and tugger method for selecting orders. When carts are used for loading, the totally refrigerated vehicle, variably refrigerated vehicle, and nonrefrigerated vehicle methods for transporting products to retail stores can be used.

Figure 13.--Nonpowered pallet jacks used to make containers mobile for use on predetermined guide path.

If the latter transporting method is used, obviously the product needs to be protected with an insulated blanket. The equipment required for the cart loading method includes load-locking bars, tracks in the side of vehicles to insert the ends of the load-locking bars, and either built-in or portable dock-boards so carts can be rolled into vehicles that are not dock height.

The third method studied was the pallet loading method. The pallet loading method engages the loaded pallets with powered pallet jacks (nonpowered pallet jacks may also be used) and positions the loaded pallets in the delivery vehicle. This method can be used with the multilevel, double-pallet pallet jack, and conveyor methods of selecting orders. The pallet loading method studied was used with the multilevel and double pallet-pallet jack selecting methods. The pallet loading method can also be used with the totally refrigerated vehicle, variably refrigerated vehicle, and the nonrefrigerated vehicle methods for transporting products to retail stores. The equipment required for the pallet loading method includes pallet jacks (powered or nonpowered), built-in or portable dock-boards, and, in some operations, tape or wraps are used on alternate pallet loads to maintain stability during travel.

Figure 14.--Tugger and insulated container used for selecting orders in firm where the predetermined guide path was used.

The fourth method studied was the insulated cart method (fig. 18). The carts are manually rolled into the delivery vehicle and secured with load-locking bars. The insulated cart method for loading delivery vehicles can be used with the insulated carts and tuggers and the insulated carts and predetermined guide path methods for selecting orders, and also with the nonrefrigerated vehicle method for transporting products to retail stores. The equipment requirements for this vehicle loading method are load-locking bars, tracks in the side of the vehicle to engage the loading-locking bar, and either built-in or portable dock boards.

Figure 15.--Single pallet jack and container used for selecting frozen food orders.

The fifth method studied was the insulated container method. In this method, powered pallet jacks are used to pickup the loaded containers and place them in the nonrefrigerated or variable refrigerated delivery vehicles. The insulated container method of loading is used with the insulated container-single pallet jack method for selecting orders and the nonrefrigerated vehicle method for transporting products to retail stores.

Delivery to Retail Stores

For purposes of this study the delivery functions are divided into two subfunctions--protecting the product during transit and transporting it to the store.

Figure 16.--Hand-stack loading of delivery truck, using conveyors to transfer cases of frozen food into the delivery truck.

Protecting the Product

When frozen foods are being transported with nonfrozen foods in the same vehicle, some method of maintaining the temperature of the frozen foods must be used. Movable bulkheads, insulated shrouds, and insulated units (insulated carts and containers) were used by the firms cooperating in this study to protect the temperature of the frozen food while it was being transported to retail stores.

Movable bulkheads.--With the movable bulkhead method for protecting frozen products, the frozen products are loaded in the front of the vehicle (where the refrigeration unit is located) and an insulated bulkhead is installed behind the frozen products (figs. 19 and 20). In addition to protecting the frozen food, the bulkhead protects the nonfrozen foods in the vehicle. The movable

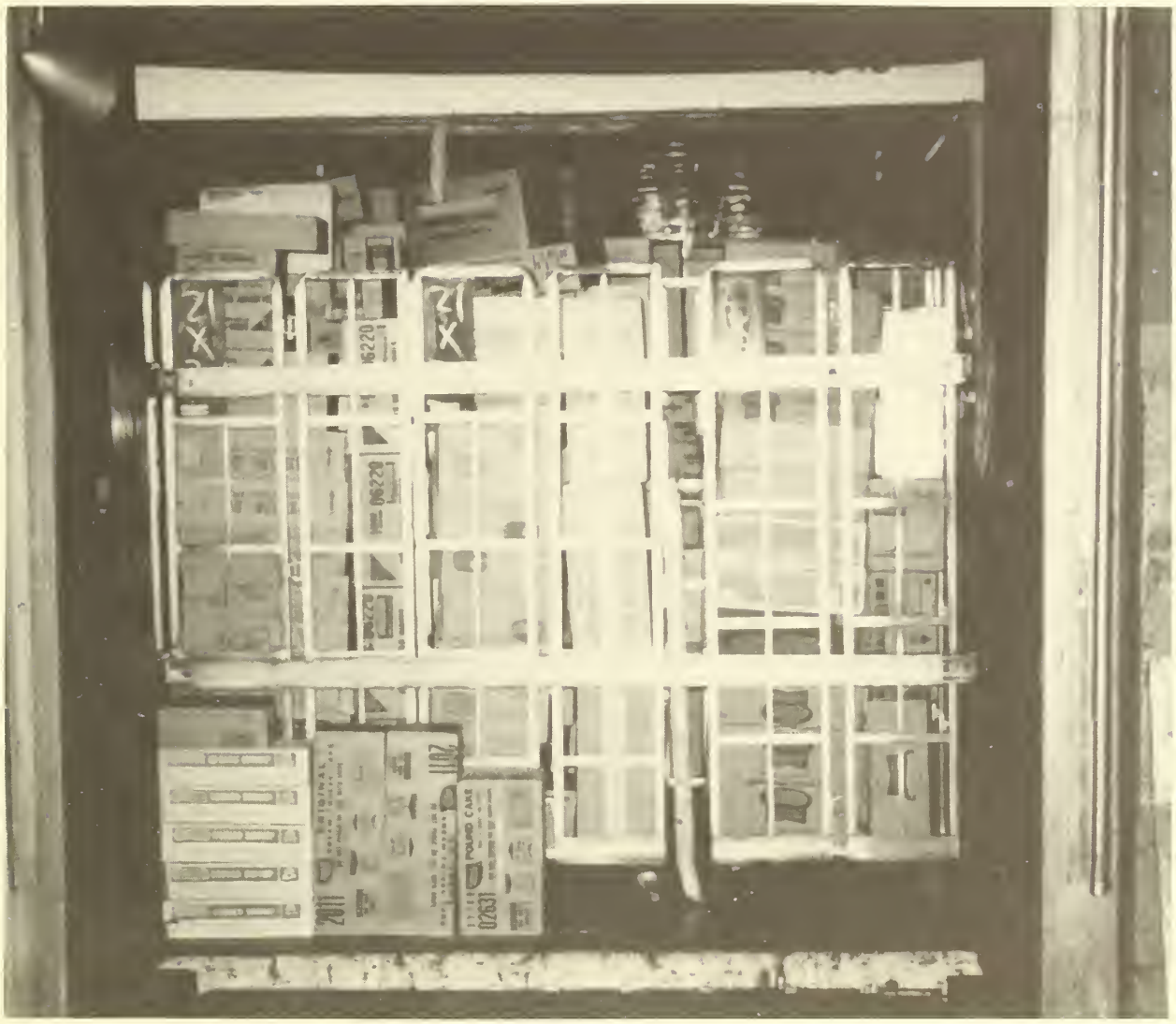

Figure 17.--Cart loads of frozen food secured in a delivery vehicle with load locking bars.

bulkhead method for protecting products can be used with the hand stacking, cart, and pallet loading methods and the variably refrigerated vehicle transporting method. The bulkhead is the only equipment required for this method of protecting frozen food during delivery.

Insulated shroud.--When this method is used to protect products during transit, the insulated shroud is placed over a loaded cart or pallet to create--in effect--a separate compartment for protecting the temperature of the frozen food. The shroud also protects other products in the load from the temperature of the frozen food. The insulated shroud method is used with the cart and pallet loading methods (the shroud is installed before loading), and also used with the variably refrigerated and nonrefrigerated vehicle

Figure 18.--Insulated cart-loads of frozen food in the shipment staging area.

transporting methods. The equipment required for this method of protecting the product is the insulated shrouds and masonite or another type of insulating layer for the base of the load.

Insulated units.--The insulated units are used to create compartments that will protect the frozen food from external temperatures and will also protect nonrefrigerated products from the low temperature of the frozen foods. The insulated units method of protecting frozen foods was used with the insulated carts and insulated containers methods for loading delivery vehicles, and the variably refrigerated and the nonrefrigerated vehicle method for transporting frozen foods to retail stores. The equipment has previously been described under selecting orders, methods 7, 8, and 9.

Figure 19.--Placing a movable bulkhead into position in a delivery vehicle.

Transporting to the Store

Transporting to the store, as used for this study, refers to the actual movement of the product from the time the vehicle leaves the warehouse dock until it is parked for unloading at the retail store. Three methods for transporting frozen food were studied--totally refrigerated vehicle, variably refrigerated vehicle, and nonrefrigerated vehicle.

Totally refrigerated vehicle.--This method of transporting could be used with any of the loading methods; however, the insulated cart and container methods would not be economical unless some stores on a multistop load did not have refrigerated holding areas. Also, this method of transporting can be used with any of the unloading methods (conveyor, dock, store lift, truck lift). The equipment required for this method is an insulated refrigerated truck.

Figure 20.--Securing a movable bulkhead in position in a delivery vehicle.

Variably refrigerated vehicle.--This method of transporting frozen food is the same as the totally refrigerated vehicle method except that a movable bulkhead is placed in the vehicle to permit shipping frozen and nonfrozen foods in the same load. All methods for selecting orders at the warehouse and unloading them at the retail store used with the totally refrigerated vehicles method could also be used with the variably refrigerated trucks and a movable bulkhead. This method of transporting allows the shipper to transport frozen, nonfrozen but requiring refrigeration, and nonrefrigerated products in the same load.

Nonrefrigerated vehicle.--This method for transporting products could be used with the cart and pallet loading methods (so long as the insulated shroud protecting method was used) and with the insulated cart and container loading methods. The dock, store lift, and truck lift unloading methods could be used with the nonrefrigerated vehicle method of transporting. The equipment required is a nonrefrigerated vehicle and some means of protecting the temperature of the product (see "Protecting the Product," page 22) from the time it leaves the warehouse until it is in the retail store.

Retail Store Handling

Retail store handling includes, for purposes of this study, unloading products from delivery vehicles. transferring products from holding area to display area, marking prices on products, and stocking display cases.

Unloading Products From Delivery Vehicles

Four methods for unloading products from delivery vehicles were studied--unloading by conveyor, unloading by dock, unloading by store lift, and unloading by truck lift.

Unloading by conveyor.--This method for unloading is performed as follows: (1) The required conveyor lengths are set up in the truck;[10] (2) cases are placed on the conveyor by the driver of the delivery vehicle; (3) store personnel remove cases from the conveyor (fig. 21). count, and sort them in family group, display-case location, and department if necessary; (4) the sorted cases are placed onto stock carts; and (5) the loaded stock carts are either moved to the display area for price marking and display case stocking or moved into storage. The conveyor unloading method was used with the hand-stacking loading method, but it also could be used with other loading methods (especially the pallet method). Unloading with conveyors permits sorting and checking for piece count while unloading. The equipment required for the conveyor unloading method includes: (1) Lengths of gravity conveyors for inside of the delivery vehicle (unless already built in); (2) a permanent or temporary conveyor set up in the store; and (3) stock carts.

Unloading by dock.--A description of this method is as follows: (1) A dock plate is positioned so units can be easily rolled from the delivery vehicle (fig. 22); (2) where carts or insulated carts are to be unloaded, the load-locking bars must be removed, the loaded carts rolled into the store, empty carts rolled into the delivery vehicle, and the load-locking bars

[10] One firm had conveyors built into the delivery vehicles. The conveyors were fastened to one side of the delivery vehicles and remained in place. Products were conveyed through a small opening in one of the larger rear doors of the vehicles. Two advantages of using built-in conveyors are: (1) Reduction in loss of cold from having large doors open: and (2) fewer lengths of conveyors in the back room of the stores. Very little space was lost in the vehicle.

Figure 21.--Unloading cases at a retail store from a delivery vehicle using conveyors.

installed; and (3) where pallets and insulated containers are to be unloaded, nonpowered pallet jacks are used to unload the units and to load the empty units. This method for unloading could be readily used with the cart, pallet, insulated cart, and insulated container methods of loading delivery vehicles, and also with the hand-stacking method (although probably very expensive) if some way other than the conveyor unloading method was used. Products unloaded by the dock method could be sorted onto stock carts for transferring to the display area, or they could be transferred in the shipping units (e.g., carts or pallets) and sorted at the display area. The equipment required for the unload by dock method includes truck-bed height docks at retail store, permanent or portable dock plates, and nonpowered pallet jacks if pallets or insulated containers are unloaded.

Figure 22.--Unloading a pallet load of frozen food from a delivery vehicle onto a dock at a retail store.

Unloading by store lift.--A description of this method for unloading delivery vehicles is as follows: (1) Store lift is elevated to truck-bed height; (2) when carts and insulated carts are to be unloaded, load-locking bars are removed, a pair of carts is rolled onto the lift (fig. 23), the lift is lowered to the ground, the full carts are rolled into the store, and empty carts are rolled onto the lift and loaded into the vehicle; and (3) where pallet and insulated containers are to be unloaded, the unloading is the same as for carts except that nonpowered pallet jacks are used to move the pallets and insulated containers. This method could be used with any of the unit load methods (carts, pallets, and insulated carts and containers) for loading delivery vehicles, and also with the hand-stacking loading method if the conveyor unloading method was not used. Any of the methods used to transfer the product to the display area (stock carts, and unit load) could also be used with the unload by store lift method for unloading delivery vehicles. The store lift is the only equipment required for this unloading method except for the nonpowered pallet jacks needed to unload pallets and insulated containers.

Figure 23.--Unloading a cart load of frozen food from a delivery vehicle using a store lift.

Unloading by truck lift.--This method may be described as follows: (1) The truck lift is moved from its retracted position to truck-bed height; (2) where carts and insulated carts are to be unloaded (fig. 24) load-locking bars are removed, a pair of carts is rolled onto the lift, the lift is lowered to ground level and the carts are rolled into the store, and empty carts are rolled onto the lift and loaded into the delivery vehicle; (3) where pallets and insulated containers are used, the truck lift is lowered to the ground first so a nonpowered pallet jack can be raised to the truck, and pallets and insulated containers are unloaded and empty units loaded similarly to the way the carts were handled. This unloading method may be used with: (1) The cart, pallet, insulated cart, and insulated container methods for loading delivery vehicles; and (2) the stock-cart or unit methods for transferring products to the display area. Except for the nonpowered pallet jacks required to unload pallets and insulated containers, a truck lift is the only equipment required for this method of unloading delivery vehicles.

Figure 24.--Unloading insulated container loads of frozen food from a delivery vehicle with a truck lift.

Sorting and Transferring Products From Holding Area to Display Area

Three methods were studied for sorting products (organizing them into display case location sequence) and transferring them to the display area--sorting in holding area and transferring by stock cart, transferring units (e.g., cart or pallet) to display area and sorting cases onto the store floor, and transferring units to display area and sorting while marking prices on the products.

Sorting and transferring by stock cart.--When unit loads cannot or should not be moved to the display area for the stocking operation, or when products are unloaded by conveyor, the frozen foods must be transferred to stock carts (fig. 25) and, to eliminate unnecessary handling, the products are sorted into

Figure 25.--Sorting cases of frozen food at a retail store onto a stock cart for transfer to the display area.

display case location sequence. The loaded stock carts are moved to the display area. This method can be used with any of the unloading methods discussed and any of the methods that will be discussed for marking prices on products. It should be noted that the conveyor method of unloading more easily permits the sorting during unloading and transferring by stock truck method than other methods of unloading. Stock carts are the only equipment required.

Transferring units to display area and sorting cases onto floor.--With this method, the carts, pallets, insulated carts, or insulated containers are moved through the aisle(s) in the display area and the cases of frozen food are placed on the floor in front of their display case location (fig. 26).

Figure 26.--Loading cases of frozen food that were sorted onto the sales floor from the shipping unit onto a stock cart for price marking.

This method could be used with the dock, store lift, and truck lift unloading methods where units (carts or pallets) were unloaded. This method could also be used with any price marking method studied. The nonpowered pallet jacks required to move pallets and insulated containers are the only equipment required for this method of sorting frozen foods and transferring them to the display area.

Transferring units to display area and sorting while pricing.--With this sorting and transferring method, the units are moved near a central location in the display area where the stockers carry cases or transport them by stock truck to the display case location (fig. 27). This method can be used with the dock, store lift, and truck lift methods for unloading delivery vehicles, and also with any price marking methods studied. The only equipment required for this operation is nonpowered pallet jacks for moving pallets or insulated containers.

Figure 27.--Sorting and price marking frozen food directly from a shipping cart.

Marking Prices on Products

Marking prices on products, as used for this study, includes positioning the case for opening, opening the case, preparing to mark prices (adjust price marking equipment when necessary), and marking the prices on the products. Four methods were studied for marking prices on products--band-stamp, label, stick-stamp, and self-inking stick-stamp methods.

The descriptions of the price marking methods in the discussion that follows will be general. The methods will vary according to: (1) The case pack--the number of layers of product per case, whether a two-layer case can be split and priced directly, or whether one layer has to be priced and removed to expose the second layer; (2) the type of packaging--cans (possibly require wiping before price marking), bags and boxes: (3) location of price on the package--prices must be marked on an area of the package where they can be easily read; and (4) the "style" or system of the stocker, the store, or the company.

Band-stamp.--With this method the stocker positions the case for opening, cuts open the case, checks the retail price, adjusts the band-stamp to the correct retail price, and marks the price on the packages of frozen food. The band-stamp method could be used with any method of sorting and transferring products and also with any method of display case stocking studied (to be discussed). The equipment required for the band-stamp method of marking prices includes the band-stamp, possibly a holster for the band-stamp, ink, and can-wiping material.

Label.--The label method is very similar to the band-stamp method, except the price is marked on a label that is attached to the package (fig. 28) rather than marked directly onto the package. In some stores, band-stamps are used with the label method to deal with items that are found hard to mark with labels. In other stores, labels are used exclusively because the product is kept frozen and the package surface is dry. The label method can be used with all methods of sorting and transferring products and all methods of display case stocking studied. The equipment required for the label method of marking prices includes label guns, possibly holsters for the label guns, labels, ink, can-wiping material, and possibly band-stamps.

Stick-stamp.--This method is very similar to the other price marking methods discussed, except that a stick-stamp requiring occasional inking (usually one "inking" will do many impressions) is used to mark the price on the product (fig. 29). Each stocker has a set of stick-stamps (in a rack or holder). Like the other price marking methods studied, this method can be used with all methods studied for sorting and transferring products, and for stocking display cases. At the stores where the stick-stamp method was studied, pricing was done in the backroom of the store and the products were transferred to the display area by stock cart. The equipment required for this method includes stick-stamps and rack, ink and wick-fed inker, and can-wiping material.

Self-inking stick-stamp.--This method is identical to the stick-stamp method described above (except the stamps are inked by the ink-pad base of their stand); it can be used with any of the sorting and transferring methods and any of the display case stocking methods.

Stocking Display Cases

Studies were conducted to determine the labor requirements and costs for stocking three types of display cases. The three types were: (1) Single-deck or "coffin" case (fig. 30), (2) multideck upright case (fig. 31), and (3) reach-in case (fig. 32).

Figure 28.--Price marking with a label gun.

ANALYSIS OF SELECTED METHODS USED FOR HANDLING FROZEN FOODS FROM WAREHOUSE RECEIVING TO RETAIL STORE DISPLAY

The discussion in this section will focus on the labor and equipment requirements and costs obtained for the frozen food handling methods studied. The labor and equipment requirements were obtained by detailed time studies of the methods. Costs were based on average labor costs of the firms studied and on 1975 prices of the equipment as reported by manufacturers.

The methods studied will be analyzed and compared in two ways. In this section, the methods will be analyzed and compared within the framework of the basic function performed. In the next section, the methods will be analyzed and compared as parts of collective systems within the overall framework of moving the frozen foods through all of the functions necessary to reach the display case at the store.

Figure 29.--Price marking with a stick-stamp.

Warehouse Handling

Receiving

The labor requirements and labor and equipment costs for unloading, transporting to reserve storage, and placing in reserve storage are shown in table 1.

Unloading.--Labor requirements and labor and equipment costs for unloading frozen foods ranged from 0.016 man-minute and 0.803 cent per case for the method using plywood sheets to 0.023 man-minute and 1.211 cents per case for one of the methods using pallets, a difference of 0.007 man-minute (44 percent) and 0.408 cent (51 percent) per case. The major reason for this difference is the easier handling of the plywood sheets and dollies than the pallets.

Figure 30.--Single-deck frozen food display case.

Transporting to reserve storage.--Labor requirements and labor and equipment costs for transporting frozen food products to reserve storage ranged from 0.007 man-minute and 0.106 cent per case for the method using forklift trucks to 0.012 man-minute and 0.155 cent per case for the method using powered pallet jacks, a difference of 0.005 man-minute (71 percent) and 0.049 cent (46 percent) per case. The major reason for the difference is the forklift truck method is a one-man operation and the powered pallet jack-forklift truck methods is a two-man operation. In addition to lower costs, the forklift truck method has the following advantages: (1) Warehouse aisles do not become clogged with stacks of pallets that block both passage in the aisle and access to pallet racks; (2) there is more flexibility and greater ease of supervision and control of manpower with one operator than with two; and (3) the movement of the forklift truck operators to the dock provides warmup for them and permits supervisors to track and coordinate activity.

Labor and equipment requirements and costs for transporting to storage with the storage-retrieval machine method are allocated to unloading or placing in storage because extensive transportation is unnecessary with the interface of the machine's pick-up/delivery stations and the dock.

Figure 31.--Multideck upright frozen food display case.

Placing in reserve storage.--Labor requirements and labor and equipment costs for placing frozen food products in reserve storage ranged from 0.029 man-minute and 1.367 cents per case for the methods using forklift trucks to 0.037 man-minute and 3.723 cents per case for the method using the storage-retrieval machines, a difference of 0.008 man-minute (28 percent) and 2.356 cents (72 percent) per case. The cost difference is due mostly to the high cost of the storage-retrieval machine and racks used with it.

Unusual cost reduction techniques were used for handling reserve storage in two of the operations studied. First the storage-retrieval machine is equipped with a remote-control "cart/lift" that transported, deposited, and removed plywood sheets within the racks. The "cart/lift," running along tracks built into the racking, is able to store plywood sheets equivalent to six pallets deep (compared to the usual one or two deep) in reserve storage. This storage capacity creates large savings in equipment and rental costs (which amount to more than 25 percent of the system's per-case cost) with minimal cost effect because labor amounts to only 2 percent of the total system cost.

Figure 32.--Reach-in frozen food display case.

The second cost reduction technique for handling reserve storage is in the use of multilevel platform trucks for selecting orders. In this operation, a "floating slot" (no fixed storage location) system virtually eliminates moving products from reserve storage to selection location. An inventory record is maintained for each product by pallet location and as one pallet of a certain product is scheduled to become empty, the computer automatically prints the next pallet location on the selection document. The key to the usefulness of the floating-slot system is the accessibility to every pallet position resulting from the use of an order-picking machine that can elevate the order selector to the level of each pallet in the system. The floating-slot system requires extensive use of computers, accurate inventory control, and frequent verification that slots are actually empty.

Totals.--Total per-case labor requirements and total per-case labor and equipment costs ranged from 0.053 man-minute (storage-retrieval machines) and 2.642 cents (transporting to reserve storage with forklift trucks) to 0.064

man-minute (transporting to reserve storage with powered pallet jacks) and 4.526 cents (storage-retrieval machines), a difference of 0.011 man-minute (21 percent) and 1.884 cents (71 percent). The major causes for the differences are: (1) The greater time required for transporting to storage in the powered pallet jack-forklift truck method, and (2) the greater cost of the equipment and installation of the storage-retrieval machine operation.

Replenishing Selection Slots

The labor requirements and labor and equipment costs for replenishing selection slots were 0.015 man-minute and 1.520 cents per case for the method using the storage-retrieval machine, and 0.033 man-minute and 0.898 cent per case for the methods using forklift trucks (table 2). The differences amounted to 0.018 man-minute (120 percent) per case in favor of the storage-retrieval machine and 0.622 cent (69 percent) in favor of forklift trucks.

The labor requirements and labor and equipment costs for moving products from an inbound delivery vehicle through reserve storage to the selection area are also shown in table 2. These ranged from 0.068 man-minute for the method using storage-retrieval machines and 3.540 cents per case for forklift trucks to 0.097 man-minute for powered pallet jack and forklift trucks and 6.046 cents per case for the storage-retrieval machine. These differences amounted to 0.029 man-minute (43 percent) and 2.506 cents (71 percent) per case. The storage-retrieval machine method had the lowest labor requirements and the highest total labor and equipment costs; the purchase and installation of the equipment accounted for 88 percent of the total cost. Using a "floating slot" system would have lowered the cost of both forklift truck methods about 10 percent: from 3.631 cents to 3.264 cents per case for the powered pallet jack-forklift truck method and from 3.540 to 3.173 cents per case for the forklift truck method.

Two comments on the storage-retrieval machine methods as used by the cooperator are pertinent. First, the selection slots (pallet rack locations) are two-deep, which enables batch selection to be conducted with minimal delay for replenishing and also increases storage density. Second, the operator of the storage-retrieval machine works in short-sleeve comfort in a controlled-environment cab.

Order Selecting

Labor requirements and labor and equipment costs for selecting frozen orders (100 to 200 cases per order)[11] ranged from 0.270 man-minute and 4.089 cents per case to 0.606 man-minute and 13.386 cents per case, a difference of 0.336 man-minute (124 percent) and 9.297 cents (227 percent) per case in favor of conveyor-manual sorting (table 3).

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[11] In order-selecting operations where "batch selection" was used, each order size was 100-200 cases, and the batch size was the number of orders in the batch multiplied by 100 to 200 cases per order.

A discussion of each of the nine methods of order selecting follows. Ranking of methods is from lowest to highest (first through ninth).

Conveyor-manual sorting method.--Four men batch-select orders for three stores onto conveyors in the freezer and four men sort from a carousel onto carts on the dock. The men rotate in pairs between selecting and sorting, resulting in less demand for warm-up time because half of the time is on the dock where the temperature is higher than in the freezer.

This method had the lowest labor requirements (0.270 man-minute per case) and total selecting costs (4.089 cents per case) of all the selecting methods studied. The lower labor requirements are a result of being able to compensate for imbalance among store orders by using the carousel in the sorting phase of this method. Using the carousel allows cases to recirculate instead of backing up and stopping the operation.

Conveyor-automatic sorting method.--For this method two pairs of selectors --with one extra selector (one-half pair) rotating through the pairs to provide time for each to get warm and batch-select orders for three stores onto a conveyor. As the selectors select a case, they place a pressure-sensitive label containing computer-printed symbols on the case. The cases are conveyed past a reader that interprets the symbols on the labels and activates a sorter. The sorter directs the cases to the appropriate delivery vehicles. In the operation studied, a sixth man monitored the sorting process. The labor requirements and total costs for selecting orders with this method are 0.402 man-minute and 9.054 cents and ranked fifth on the basis of labor requirements and seventh on the basis of costs.

Compared with the conveyor-manual sorting method, this method has a 0.132 man-minute or 49 percent greater labor requirement (0.402 man-minute - 0.270 man-minute). The higher labor requirement, indicating lower productivity, comes from imbalances between order sizes which cause backups that shut down the selecting operation. Expansion of the operation would ease the backup problem by adding to the accumulation capacity of each loading line. Adding to the accumulation capacity of each loading line cushions the effect of order-size imbalance by allowing time for assistance to reach the problem line and keep the operation flowing.

Conveyor-single store method.--For this method five people select orders and one person monitors the product flow and merges the flow of the conveyor lines into the conveyor going into the proper delivery vehicle. A problem in this operation is backup, because all five selectors are needed to select orders. A solution to both problems (productivity and capacity) is to convert the operation to a batch-selecting and loading operation for two or three stores. Converting to a batch operation would relieve the backup in the loading part of the operation and permit enough selectors to meet the expanding output needs. Naturally, the operation must be carefully designed to avoid

problems encountered with the conveyor-automatic sorting method. In terms of total order-selecting labor requirements and costs the conveyor-single store method required 0.336 man-minute and cost 4.369 cents per case and ranked third in terms of both requirements and costs.

Carts and tuggers method.--Relative to the preceding methods, the carts and tuggers method is very uncomplicated. An order selector hooks a train of carts to a tugger, places selected cases on the carts, and parks the loaded carts in the shipment-staging area. The major advantage of this method (also for other single-selector methods) over the conveyor methods is the total flexibility in the number of order selectors required at any given time. The conveyor methods required teams of order selectors, and balancing order sizes was a problem except where the carousel was used in the order sorting phase. Another advantage of the carts and tuggers method (and other single-selector methods) is that order selectors come to the dock frequently to park loaded carts in the shipment-staging area, giving them some warmup time in the process. The total selecting labor requirements and costs for carts and tuggers method amounted to 0.450 man-minute and 6.257 cents per case and ranked sixth on the basis of labor requirements and ranked fifth on the basis of costs.

Pallet and double pallet jack method.--Like the carts and tuggers method, this method is uncomplicated relative to the conveyor methods, extremely flexible in terms of the number of selectors required at any given time, and offers warmup time to selectors when they park the loaded pallets on the dock. The use of pallets requires low equipment investment and simplifies loading and unloading. Unlike carts and containers, empty pallets do not occupy a large amount of trailer space, thus enabling the distributor to backhaul products on the return trip from the retail stores and to more easily unload when making more than one stop per truckload. However, two problems were apparent. First, accurate load-checking is impossible because of hidden cases in the center of the pallet load. Second, store doors and passageways are often not wide enough to maneuver pallets easily, thereby increasing the tendencies to leave the product out of refrigeration while awaiting stocking. In terms of requirements and total selecting costs, this method amounted to 0.342 man-minute and 4.363 cents per case and ranked fourth on the basis of labor requirements and second on the basis of costs.

Multilevel-pallets method.--This method requires two order selectors and a dockman who spends one-half of his time taking loaded pallets from the selectors and supplying them with empty pallets. The order selectors stand on a platform of the order-selecting machine and place selected cases onto pallets. Radiant heaters, operated on power supplied from a bus bar in the guide rail, warm the selectors so they can work relatively unencumbered either by the cold or by heavy protective clothing. This method ranked second in labor requirements (0.294 man-minute) and fourth in total selecting costs (4.805 cents per case).

Insulated carts and tuggers method.--This method is similar to the carts and tuggers method in its flexibility in numbers of selectors needed, and its provision for frequent trips to the dock allowing selectors some warmup time. The rationale for the insulation is the ability to ship the frozen foods on nonrefrigerated trucks with other products (typically dry groceries) at virtually no additional transport costs due to available space on the truck. Without such "free ride" capability, the combination of high labor costs (highest of methods studied), high equipment costs (highest of methods studied), and low truck capacity (735 cents per truckload vs. 1,500; 1,800; and 2,200 cases per truckload for conventional carts, pallets, and hand-stacked loading, respectively) would make the use of this sytem totally undesirable. In terms of labor requirements and total selecting costs, this method amounted to 0.606 man-minute and 13.386 cents per case and ranked ninth on the basis of both requirements and costs.

Predetermined guide path method.--For this method a train of insulated containers on nonpowered pallet jacks is hooked to a powered pallet jack. The train is pulled along a guide path in the aisle. The basic rationale for using insulated containers is the ability to reduce transportation costs when it is possible to have the frozen foods move on a "free ride" with dry groceries. With a truckload factor of 684 cases, the container would be uneconomical relative to the other methods studied. The guide path aspect of this selection method has both advantages and disadvantages compared to the following insulated container-single pallet jack method, but its slightly lower labor costs are more than offset by higher equipment costs. The advantage of this method is reduced labor requirements resulting from selectors not having to mount and dismount machines each time the train has to be moved and not having to return to the dock with each container load. Traffic problems arose in the warehouse where the insulated container-guide path method was studied that virtually eliminated many potential gains. When there were two or more selectors in the aisle, the guide path could not be effectively used because of the necessity of selectors to pass each other. Also, two selectors with their trains could not work in the same portion of the aisle. As a result, a large portion of the selection was done by the insulated container-single pallet jack method.

The requirements and total selecting costs were 0.486 man-minute and 9.788 cents per case and ranked seventh on the basis of requirements and eighth on the basis of costs.

Insulated containers-single pallet jack method.--For this method an order selector places a pallet jack under an insulated container and moves to the order selection area. When the container is loaded or the order selected, the order selector moves the containers to the dock. This method is highly flexible in that it provides the opportunity to adjust the size of the selecting crew to fit the selection volume without being concerned about teams, balancing order sizes, or aisle traffic (within reasonable ranges of facility size and activity). Also, the frequent movement of the selectors to the dock eases pressures for more warmup time. However, as with the other insulation methods, the basic rationale is to permit shipping frozen foods on nonrefrigerated trucks with grocery products. Without the ability to transport the frozen foods at no

additional transport costs, the method is not economical. Labor requirements and total selecting costs amounted to 0.516 man-minute and 8.984 cents per case and ranked eighth on the basis of requirements and sixth on the basis of costs.

Truck Loading

Labor requirements and labor and equipment costs for loading frozen food orders onto delivery vehicles ranged from 0.017 man-minute and 0.220 cent per case for the pallet methods to 0.153 man-minute and 1.637 cents per case for the average of the hand-stacking methods (table 3), a difference of 0.136 man-minute (800 percent) and 1.417 cents (644 percent) per case.

Pallet loading was the lowest cost method, following by the cart method, the insulated container method, the insulated cart method, and the hand-stacked method.

Delivery

Delivery, as used in this study, includes protecting the products and transporting them to the retail store. Defining delivery in this manner eliminates the effect of selecting, loading, and unloading on the cost of delivery. For example, an order that is selected onto carts will be loaded by carts, transported by carts, and unloaded by carts.

Protecting the Product

Unless frozen foods are transported in a totally refrigerated vehicle they must be protected from warm temperatures. Three methods were studied for protecting frozen foods during transit--insulated carts and containers, movable bulkheads, and insulated shrouds.

The insulated carts and containers method for protecting products were discussed under "Order Selecting," and costs for using them were charged to order selecting.

Although the temperature-holding ability of insulated shrouds is less than that of insulated carts and containers, shrouds have three advantages. First, the cost and space required to stockpile insulated carts and containers (fig. 33) are substantially greater than to stock-pile insulated shrouds (fig. 34). Second, the space required at the store for empty shrouds plus folding carts or pallets is much less than for insulated carts or containers (rigid carts would reduce the difference). Finally, empty folding carts, pallets, and insulated shrouds take less room in the delivery vehicle than empty insulated carts and containers. This final advantage is very important in backhauling products.

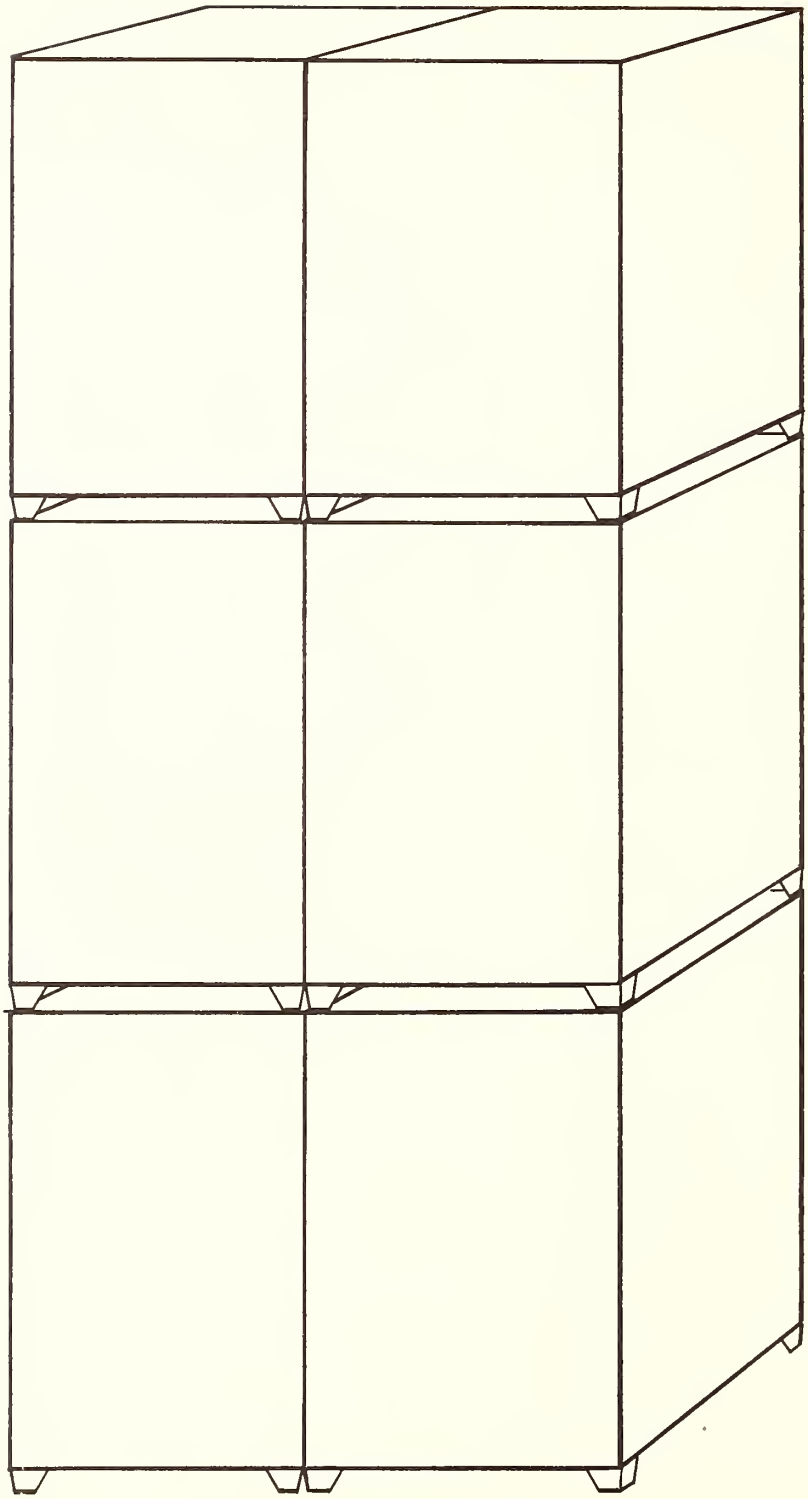

Figure 33.--Insulated containers stockpiled until required for shipping.

Figure 34.--Insulated shrouds stockpiled until required for shipping.

Transporting to Retail Stores

Transportation costs for frozen foods ranged from 0 to more than 7 cents per case. The zero costs are explained by the addition of frozen foods to a nonfrozen food delivery system (e.g., groceries or produce), thereby eliminating one delivery trip; therefore, for purposes of this analysis, no additional transport cost is charged to frozen food. In cost accounting procedures, some of the transport costs would be allocated to each of the products being transported. However, the net effect is the same because the transportation costs added to frozen foods would be subtracted from the transportation costs of nonfrozen foods.

Movable bulkheads are used in totally refrigerated delivery trucks when frozen foods and nonfrozen foods are being delivered on the same load. The frozen foods are loaded into the front of the vehicle and the bulkhead is placed behind the frozen foods. Then the nonfrozen foods are loaded behind the bulkhead. The cost of installing the bulkheads and the annual ownership cost of the bulkheads amounted to 1.54 cents per case shipped.

Insulated shrouds are placed over cartloads or pallet loads of frozen foods before they are loaded onto the delivery truck. The insulated shrouds are used when frozen foods are being delivered with nonfrozen food on an unrefrigerated truck. Installation and annual ownership costs of the shrouds amounted to 1.30 cents per case shipped.

In addition to protecting products during transit, insulated shrouds and insulated carts and containers protect frozen foods for extended periods in the backrooms of retail stores. Also, insulating the product eliminates the necessity to immediately place the product into cold storage upon arrival at the store. The insulated carts and containers held the temperature of the frozen food substantially better than the insulated shrouds (1° increase per 24 hours with insulated carts and containers vs. 1° increase per hour with insulated shrouds).

The ability to take advantage of the frozen-nonfrozen delivery potential obviously depends on the ability of the frozen food supplier to combine the transport and delivery of frozen foods with other food products. The advantage of the frozen-nonfrozen delivery results from the elimination of the separate delivery runs to deliver each product.

For purposes of comparing transportation costs, consider the following typical situation for some of the cooperators in this study:

1. Assumptions:

    a. A delivery run consists of four stops and 135 miles.

    b. Time required for the drive to make the trip (not including unloading) is 450 minutes.

    c. One day of tractor and trailer time is required to make the trip.

    c. A 40-foot refrigerated trailer is used for delivery; the capacity of the trailer is 2,200 cases of hand-stacked loads, 1,800 cases for pallet loads, and 1,500 cases for cartloads.

    e. No cost for delivery is charged to frozen products shipped in variable refrigerated or nonrefrigerated vehicles.

2. Cost factors:

    a. Driver = 450 man-minutes x 10.7 cents per man-minute = $48.15.

    b. Tractor lease = 1 day x $23.93 per day = $23.93.

    c. Trailer lease = 1 day x $19.65 per day = $19.65.

    d. Mileage = 135 miles x 13.79 cents per mile = $18.62.

    e. $48.15 (driver) + $23.93 (tractor) + $19.65 (trailer) + $18.62 (mileage) = $110.35.

3. Cost per case:

   a. Hand-stacked = $110.35 (total cost) ÷ 2,200 cases per load = 5.016 cents per case.

   b. Pallets = $110.35 (total cost) ÷ 1,800 cases per load = 6.131 cents per case.

   c. Carts = $110.35 (total cost) ÷ 1,500 cases per load = 7.357 cents per case.

4. Comparison of costs per case:

   a. Hand-stacked loads had lowest transportation costs.

   b. Pallet loads cost 1.115 cents (22 percent) per case more to transport than hand-stacked loads.

   c. Cartloads cost 2.341 cents (47 percent) per case more to transport than hand-stacked loads, and 1.226 cents (20 percent) per case more to transport than pallet loads.

From the above example the following conclusions can be drawn with respect to transport costs. First, for transporting loads up to 1,500 cases, use any of the three methods. Second, for transporting loads calling for 1,800 cases, hand-stack or use pallets. Finally, for transporting loads calling for 2,200 cases, use hand-stacked loading. Obviously the above conclusions may be different when distance or the number of stops per load varies from those of the example. Also some stores may not be able to receive unit loads.

When insulated carts and containers are used, the hauling capacity of the delivery vehicle is reduced. In a 40-foot trailer, only 735 cases in insulated carts and 684 cases in insulated containers can be delivered. Insulated carts and containers would normally not be used in full truckload deliveries, only in mixed-load deliveries.

Retail Store Handling

Unloading

Four methods used for unloading frozen foods at retail stores were evaluated--conveyor, dock, store lift, and truck lift. The labor requirements and labor and equipment costs for the four methods of unloading are shown in table 4.

According to data shown in table 4, when unitized loads (carts, pallets, etc.) are shipped, the dock unloading method is the most efficient and least expensive. However, not every retail store is equipped with a dock, so some other method of unloading (store lift or truck lift) is required. The truck lift unloading method is more efficient and less costly than the store lift unloading method within the overall handling system for frozen foods.

The conveyor method of unloading is used when products are hand-stacked in the delivery vehicle. This method can also be used with unitized loads; however, it negates many of the economies of unitized shipments.

Sorting and Transferring to Sales Area

When frozen products arrive at the retail store, they usually have to be sorted into groups of what is needed now and what has to be stored for later use. In addition, the products must be transferred to the sales area or the storage area. In some operations cases are sorted from unit loads onto stocking carts for transfer to the sales area, and in other operations unit loads are moved to the sales area and products are sorted onto the sales floor or are sorted, priced, and stocked directly from the unit load. Naturally, when products are unloaded by conveyor they can be loaded directly onto stock carts instead of transferring them to stock carts later. The usual practice is to count and sort the products as they come off the conveyor line and to immediately transfer the loaded stock carts to the display area or to the cold storage area. When stock carts are used, the products are exposed to higher temperatures for a much shorter time than when larger units (e.g., pallets and carts) are used.

The labor requirement and labor and equipment costs for transferring frozen foods from retail receiving to sales area are shown in table 5. No requirements and costs are shown for products received by conveyor because unloading and sorting were performed as one operation, and these requirements and costs are included in the unloading costs. The most efficient and least expensive transfer method is the one using stock carts (0.145 to 0.154 man-minute per case and 1.593 to 1.688 cents per case). The most expensive method is moving units to the sales area and sorting products onto the sales floor (2.661 to 3.150 cents per case), averaging 87 percent more than the stock cart method.

Besides being less expensive, the stock cart method may be used for transferring products during business hours. Stock carts are small, easily maneuvered, and do not greatly hinder customer flow. In comparison, unit loads are large, unwieldly, hinder customer flow, and block large areas of the display. Also, when unit loads are moved to the sales floor some products may be out of refrigeration for up to 3 hours during price marking and display case stocking.

Price Marking and Display Case Stocking

The final steps in getting the frozen food products to the consumer are price marking and display case stocking.

Price marking.--Four methods, based on equipment used, were evaluated for price marking--band stamps, labels, stick stamps, and self-inking stick stamps. All of the methods had some common elements. First, the quality of the results depended upon a combination of motivation, training, and care taken. Second, the package surface must be clear of moisture, frost, or other films (some juice cans had a light film of oil on the ends of the cans) so that stamped prices are legible or so that labels will adhere. If products are held at low temperatures,

if they are price marked shortly after they have been removed from refrigeration, and if display cases are operating properly, price legibility and label adherence are no problems (except for oily juice cans). However, in many stores a cloth or a glove is used to wipe the surfaces of the package as well as the end of the juice cans. Thus, wiping becomes part of the price marking operations.

An additional means of pricing the product quickly after withdrawal from refrigeration is to locate price marking in the backroom. Pricing in the back reduces the time between refrigeration and pricing by more than half compared with the combined functions (price marking and shelf stocking); it also offers other advantages that will be discussed in the analysis of the individual methods.

The labor requirements and labor and equipment costs for price marking frozen food in retail stores are shown in table 6.

One (and the most expensive) price marking method studied was the band stamp. Although the band stamp had the lowest equipment cost (0.176 cent per case), the labor costs (10.427 cents per case) for this method more than offset the reduced equipment cost. Besides having the highest total costs (10.603 cents per case), the band stamp method also presented the poorest price mark relative to the other price marking methods.

A major rationale offered for the use of the band stamp method was to mark items--such as bags of frozen foods--that store personnel believe could not be effectively marked with labels. However, the rationale did not appear to be valid because labels have been used successfully for price marking bags of frozen foods in many stores. Technique rather than equipment seemed to be the key to successful price marking.

The second, and the second most expensive, price marking method (9.708 cents per case) studied was the label method. The label method for price marking frozen foods is growing in popularity for the following reasons: (1) The quality of the price mark is much better (price is printed onto a label by a gun and the label applied to the package compared with printing the price directly onto a package surface that may be on an angle, irregular, or filmed over); (2) the price on the label is easier to find and to read by both the customer and checkout person; (3) store and department data can be printed on the labels or indicated by different colors and shapes of labels; and (4) price changing is easier with labels. The label method is about 0.6 cent per case higher than the two stick stamp methods (9.708 vs. 9.125 and 9.166 cents per case). Criticisms of the label method are difficulty with getting labels to adhere to packages and cost of labels. In this study, the cost of labels averaged about one-twentieth of a cent per case.

The third, and the least expensive, price marking method (9.125 cents per case) studied was the stick stamp method. The use of the stick stamp method has been substantially reduced as more stores are turning to the label method. In the hands of well-trained and motivated personnel, however, the stick stamp method continues to be very effective and a little less expensive than other methods being used.

In the stores studied, stick stamp pricing was done in the backroom, where a well-designed work station was set up. The worker marking the prices took a case of products from a stock cart, cut the case open, marked prices on the packages, and replaced the case on a stock cart (a multishelf cart was more practical than a single shelf cart when cases were replaced on the cart as they were price marked).

There are three major advantages of price marking in the backroom. First, the quality of the marking is excellent. Not only is an expert worker able to concentrate upon the demanding price marking process (without reducing time availability by spending it in the far-less-demanding stocking process), but the worker can apply the price much more easily and consistently at a standard-height, well-designed work station than in an aisle. A second advantage of backroom price marking is that stock carts are in the store aisles less than half the time required when both price marking and display case stocking are done in the aisles. A third major advantage of backroom price marking is being able to use less experienced workers to stock the display cases. If price marking and display case stocking are done in the sales area, the more skilled worker must do both. Observations and discussions with store managers show lack of trained people is the typical source of price marking problems with any of the methods studied.

The fourth method of price marking was the self-inking stick stamp method. The difference between the two stick stamp methods is the base in which the otherwise identical stick stamps are kept. Inasmuch as the stick stamp themselves hold enough ink to permit 600 to 800 impressions without reinking, the advantage of the self-inking base is negligible. The additional labor involved in periodically touching any stick stamp to an ink can with a built-in pad cannot be measured.

Display case stocking.--Three types of frozen food display cases were selected for stocking studies--single deck (often referred to as "coffin" type), multilevel upright, and reach-in. The labor requirements and costs shown in table 7 were obtained from stores where price marking was done in the backroom and the products were transferred to the sales area by stock carts. The cost range for stocking the three display cases was approximately 1.1 cents per case, with the single-deck type of display case being the less costly to stock.

Conclusions

Based on the analyses of individual methods presented in this section, the following conclusions may be summarized.

1. Using forklift trucks for unloading, moving to storage, and placing products into storage is less expensive than using powered pallet jacks and forklift trucks, or using storage-retrieval machines. Although the latter had lower labor costs, they were more than offset by higher equipment costs.

2. Forklift trucks are less expensive than storage-retrieval machines for replenishing pallet racks used for selection storage.

3. Conveyor-manual sort-mobile cart method is less expensive than the other eight methods evaluated for shipping frozen foods.

4. Hand-stacked loads are less expensive to transport than unit loads when straight loads of frozen food are being transported.

5. Docks at retail stores are less expensive for unloading unit loads of frozen foods than store lifts or truck lifts. Truck lifts were less expensive than store lifts where no docks were available.

6. Stock carts for moving products from retail store receiving to the sales area are less expensive than sorting products from unit loads onto the sales floor or stocking directly from the unit loads.

7. Stick stamps for price marking are less expensive than band stamps, labels, and self-inking stick stamps.

8. Stocking single-deck (coffin) display cases is less expensive, but there is very little difference in costs for stocking single-deck, multilevel-upright, and reach-in display cases.

ANALYSIS OF SELECTED SYSTEMS USED FOR HANDLING FROZEN FOODS FROM WAREHOUSE RECEIVING TO RETAIL STORE DISPLAY

In this section, the objective is to combine the various methods discussed in the preceding section into the systems that were used by firms cooperating in this study to move frozen foods from warehouse receiving to retail store display. The handling costs and requirements are discussed first, followed by facility rental costs.

Warehouse

Warehouse costs ranged from 7.667 to 17.983 cents per case (table 8) and average 11.705 cents. Warehouse labor requirements ranged from 0.369 to 0.780 man-minute per case and averaged 0.561 man-minute per case. Labor accounted for 51 percent of the warehouse costs (range = 41-63 percent).

The lowest cost system (7.667 cents per case) was System F (forklift trucks, multilevel selection onto pallets). System F also had the lowest total labor requirements (0.369 man-minute per case). The reasons for System F having the lowest costs were: (1) No replenishing was necessary because a floating slot system was used; (2) the system had the second lowest shipping costs and requirements. System C (forklift trucks, conveyor selection, manual sorting onto carts) ranked a close second in both costs (7.876 cents per case for System C vs. 7.667 for System F--a difference of 0.209 cent or 2 percent) and labor requirements (0.382 man-minute per case for System C vs. 0.369 for System F--a difference of 0.013, or 4 percent). System G (forklift trucks, insulated carts and tuggers) had the highest costs (17.983 cents per case) and labor requirements (0.780 man-minute per case).

Retail Store

Total retail store costs and labor requirements ranged from 16.560 cents and 1.540 man-minutes per case to 20.209 cents and 1.740 man-minutes per case, a difference of 3.649 cents (22 percent) and 0.200 man-minute (13 percent) (table 9). Of the total retail store costs, an average of 95 percent (range = 95-98 percent) were for labor.

Systems A and B (both conveyor receiving) had the lowest total retail costs and labor requirements, because of ability to sort products onto stock carts for transfer to the sales area during unloading. With other systems, the units had to be unloaded from the delivery vehicle, then the cases of products had to be sorted. System G (insulated carts, store lifts) had the highest retail store costs and requirements; the major reason for these highest costs and requirements was the smaller carrying capacity of insulated carts relative to other units.

Total Labor and Equipment Costs

The total costs and labor requirements for the nine systems evaluated are shown in table 10. Total costs ranged from 30.774 to 39.647 cents per case, a difference of 8.873 cents or approximately 29 percent. Total labor requirements ranged from 2.322 to 2.656 man-minutes per case, a difference of 0.334 man-minute or approximately 14 percent. An average of approximately 72 percent of the total per-case costs was for labor. Costs and labor requirements at retail stores accounted for an average of approximately 50 percent of total per-case costs and approximately 68 percent of total per-case labor requirements. Warehouse costs and labor requirements accounted for an average of approximately 36 percent of total per-case costs and approximately 23 percent of total per-case labor requirements. Delivery costs and labor requirements accounted for approximately 14 percent of total per-case costs and approximately 9 percent of total per-case labor requirements.

System B (forklift trucks, conveyor selection of single store orders, conveyor unloading) was the lowest cost system--30.774 cents per case (table 11). System G (forklift trucks, insulated carts and tuggers, store lift unloading) was the highest cost system--39.647 cents per case. The difference between the lowest and highest cost systems was 8.873 cents per case or approximately 29 percent. In a hypothetical frozen food distribution operation serving 150 stores with each store receiving an average of 200 cases three times per week a cost difference of 8.873 cents per case would amount to approximately $415,000 per year. Assuming an average retail price of $8 per case, a $415,000 cost difference would amount to approximately 1 percent of sales.

Although System B with conveyor unloading at retail store was the lowest cost system, the difference between the two lowest cost combinations of handling systems and retail store unloading methods was less than 1 cent per case (table 11).

Frozen food distribution operations cannot adopt the least costly system for each existing retail unloading method. For example, adopting System B for serving stores where unloading is done with conveyors, System I for serving stores where unloading is done with docks, and System F for serving stores when unloading is done with truck lifts and store lifts is not practical. Therefore, the problem

becomes one of selecting the best system to combine with the various retail store unloading methods. The average costs and requirements per case for the various combinations of handling systems and retail store unloading methods are shown in table 12.

Up to this point in the analysis, one of the assumptions has been that products were delivered to retail stores in totally refrigerated vehicles for Systems A through F, and with groceries in nonrefrigerated trucks for Systems G, H, and I. This assumption may have caused some biased results. Therefore, to check its impact, the requirement that products in Systems A through F be shipped in totally refrigerated vehicles will be dropped. Obviously, products from Systems A and B, which are hand stacked in delivery vehicles, will have to be refrigerated. However, insulated blankets or shrouds can be used to protect the products in Systems C, D, E, and F from warmer temperatures, although not as well as insulated carts or containers.

The results of deducting the transportation costs and adding the extra labor and equipment costs associated with the insulated shrouds are shown in table 13. Comparing data shown in tables 12 and 13 shows the great impact of transportation costs on frozen food handling systems.[12]

System C (used with the following retail store handling method: sorting products onto stock carts for transfer to the sales area; price marking with stick stamps; and stocking single-deck display cases) became the lowest-cost system (26.605 cents per case). System B, which was the lowest cost system prior to altering the method of protecting the product, now ranked fifth (30.774 cents per case).

Facility Rental Costs

One additional set of factors to be considered in this analysis is facility cost (for the warehouse). The facility rental costs for the systems studied are as follows: (1) System A = 3.305 cents per case, (2) System B = 8.473 cents per case, (3) System C = 3.948 cents per case, (4) Systems D and E = 5.575 cents per case, (5) System F = 10.520 cents per case, (6) System G = 5.634 cents per case, and (7) Systems H and I = 6.007 cents per case.[13]

The high facility rental costs for System F (multilevel selection) is a result of two factors. First, the facility housing the warehouse part of System F is a low-ceiling (17 feet clear) facility which causes the cost per square and per cubic foot to be higher than for facilities having greater ceiling heights. Second, order selecting and transporting to storage are performed in separate aisles, causing additional space requirements relative to methods where all product handling is conducted in the same aisles.

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[12]For a thorough discussion of the impact of transportation costs on frozen food handling costs, see: Karitas, James J. Costs of delivering groceries and frozen foods to restaurant in combined or separate loads. U.S. Dept. Agr. Mktg. Res. Rpt. 1060, 28 pp. 1977.

[13]Costs are based on 31 percent of 1975 construction costs in the Boston, Mass., area for exactly duplicating the actual facilities used by cooperators.

The average per-case handling and warehouse facilities rental costs for the frozen food handling systems evaluated are shown in table 14. According to the data in table 14, System C, when used with store docks for unloading products at retail stores; stock trucks to transfer products from retail receiving to the sales area; stick stamps for price marking; and single-deck frozen food display cases, is the lowest cost system (37.781 cents per case) for handling frozen foods from warehouse receiving to retail store display.

In addition to determining the lowest cost system, some other comparisons offer useful information. First, Systems D and E provide comparison of cart (D) and pallet (E) systems for handling frozen food from warehouse to retail store. System E (powered pallet jack, forklift truck, double pallet jack and pallets, dock) is approximately 2.7 cents per case (41.576-38.902) less costly than System D (forklift trucks, tuggers and carts, dock). If the increased cost of using the powered pallet jack (0.096 cent per case) in System E was deducted, System E would be approximately 2.8 cents per case less than System D. Using the example of the hypothetical distribution operation (page 54), the 2.7 cents per case cost difference would amount to approximately $126,360 annual savings in favor of System E. Therefore, the system using pallets (System E) would be recommended over the system using carts (System D).

One other comparison that can be drawn from the data appearing in table 14 is between the three systems using insulated units (Systems G, H, and I). System I--forklift trucks, insulated containers, docks--is 0.805 cent per case less (39.682-38.877 cents per case) than System H--forklift trucks, insulated containers on predetermined guide path, docks--and 5.059 cents per case less (43.936-38.877) than System G--forklift trucks, insulated carts and tuggers, docks. Based on the earlier hypothetical example (page 54), the annual savings from using System I would amount to approximately $38,000 over using System H and approximately $237,000 over using System G. Therefore, where maintaining product temperature throughout the distribution operations is a problem, System I should be considered.

Conclusions

Based on the analyses of systems used to handle frozen foods from warehouse receiving to retail store display the following conclusions may be summarized:

1. When only handling costs are considered, the following systems should be selected: Use forklift trucks for handling products from warehouse receiving to storage and from storage to selection area, select single orders onto conveyors, hand stack store orders into delivery vehicles, and use conveyors for unloading at retail stores. At the retail store, use stock carts to transfer products from retail receiving to the sales area, stick stamps for price marking, and single deck display cases.

2. When the system is committed to unit-load (carts, pallets, or containers) handling of retail store orders, and only handling costs are being considered, one of the following systems is recommended: (a) Use forklift trucks for handling products from warehouse receiving to storage, no movement of product from storage to selection area, multilevel selection, and pallet for shipping to retail stores, or (b) use forklift trucks for handling products from warehouse

receiving to selection area and insulated containers and pallet jacks for selecting orders and shipping them to retail stores.

3. When insulated shrouds rather than totally refrigerated trucks are used to protect the products during delivery or total handling and when facility rental costs are considered, use forklift trucks to transfer products from receiving to storage and from storage to selection, batch-select store orders onto conveyors, manually sort store orders, use carts to unitize loads for delivery, use docks for unloading at retail stores, sort products from unit carts onto stock carts in the backroom of the retail store for transfer to the sales area, use stick stamps for price marking, and use single deck display cases.

4. When unitized handling of frozen food on either carts or pallets in nonconveyorized operations is considered, the evidence presented shows the system using double pallet jacks and pallets to be less costly than the system using tuggers and carts.

5. Finally, when choice of an insulated unit system is considered, the system using forklift trucks, insulated containers, and docks at retail store is less costly than the system using forklift trucks, insulated containers on a predetermined guide path, and docks at retail store.

IMPACT OF FACILITY HEIGHTS ON FROZEN FOOD WAREHOUSE CONSTRUCTION AND RENTAL COSTS

As shown in the previous section, facility costs can have a major impact on the overall costs of handling frozen foods from warehouse receiving to retail store display. Facility rental costs ranged from approximately 8 percent (System A) to 24 percent (System F) and averaged approximately 15 percent of total handling and facility rental costs shown in table 14. The purpose of this section is to show and discuss the impact that constructing facilities with higher ceilings might have on facility costs.

In order to measure the impact of increased facility-ceiling heights the following assumptions were made: (1) The maximum lift height for a forklift truck was 32 feet or 9 pallet loads high; (2) the maximum lift height for the storage-retrieval machine used was 36 feet or 10 pallets high; (3) storage requirements were based on the actual inventory per item in the firms studied; (4) if order selection was done from the floor, the height limitation was two pallets (8 feet) for selection plus the necessary overhead storage requirements; and (5) if order selection involved using conveyors, the height limitation was in multiples of two pallets. In all cases the relative area-to-height relationship was calculated to expose the appropriate number of selection positions to the order selectors. Given the above assumptions, construction costs were calculated for each facility, using the same material, point-in-time, and location.

The actual and alternate construction dimensions and costs and annual rental costs for the systems studied are shown in table 15. The annual rental cost savings ranged from 0.276 cent to 2.068 cents per case as a result of the "alternate" or higher-ceiling facility. The estimated reduced facility rental

cost resulting from using the "alternate" warehouse changed the ranking of systems shown in table 13. System B ranked second and System I, fourth.

In addition to cost savings, the comparison of "actual" and "alternate" warehouse facilities shows the importance of facility and equipment planning. The warehouse equipment (storage-retrieval machines, conveyors) used in System A was selected, and the warehouse was designed for the equipment. Therefore, very little facility rental cost reduction can be gained by increasing the ceiling height of the warehouse used with System A.

The impact of greater warehouse ceiling heights on facility costs may be summarized as follows. Increased height reduces warehouse construction and facility rental costs. Handling equipment and facilities should be planned so they do not limit the stacking height capabilities of the equipment.

TABLES

TABLE 1.--Labor requirements and labor and equipment costs for 3 methods of receiving frozen foods in food warehouses

Method	Labor requirement		Labor cost[1]		Equipment cost[2]		Total costs	
	Man-minute per case	% higher than lowest method	Cents per case	% higher than lowest method	Cents per case	% higher than lowest method	Cents per case	% higher than lowest method
Storage-retrieval machines:								
Unload (plywood sheets)	0.016	--	0.171	--	0.632	--	0.803	--
Transport to storage[3]	--	--	--	--	--	--	--	--
Place in storage	.037	28	.395	28	3.328	100	3.723	72
Total	.053	--	.566	--	3.960	95	4.526	71
Powered pallet jack-forklift truck:								
Unload (pallets)	.023	44	.246	44	.965	53	1.211	51
Transport to storage	.012	71	.128	71	.027	--	.155	46
Place in storage	.029	--	.311	--	1.056	--	1.367	--
Total	.064	21	.685	21	2.048	1	2.733	3
Forklift truck:								
Unload (pallets)	.022	38	.235	38	.934	48	1.169	46
Transport to storage	.007	--	.075	--	.031	15	.106	--
Place in storage	.029	--	.311	--	1.056	--	1.367	--
Total	.058	9	.621	9	2.021	--	2.642	--

[1]Based on labor costs, including fringes, of $6.43 per hour as reported by firms cooperating in study.
[2]Includes depreciation, interest, maintenance, and power. See appendix tables 16, 20, and 21.
[3]Included as part of unloading and placing in storage subfunctions.

TABLE 2.--Labor requirements and labor and equipment costs for 3 methods of handling frozen foods from receiving through selection slot replenishing in food warehouses

Method	Labor requirement		Labor cost[1]		Equipment cost[2]		Total costs	
	Man-minute per case	% higher than lowest method	Cents per case	% higher than lowest method	Cents per case	% higher than lowest method	Cents per case	% higher than lowest method
Storage-retrieval machines:								
Receiving[3]	0.053	--	0.566	--	3.960	95	4.526	71
Replenishing	.015	--	.160	--	1.360	107	1.520	69
Total	.068	--	.726	--	5.320	107	6.046	71
Powered pallet jacks-forklift truck:								
Receiving[3]	.064	21	.685	21	2.048	1	2.733	3
Replenishing	.033	120	.353	120	.545	--	.898	--
Total	.097	43	1.038	43	2.593	1	3.631	2
Forklift truck:								
Receiving[3]	.058	9	.621	9	2.021	--	2.642	--
Replenishing	.033	120	.353	120	.545	--	.898	--
Total	.091	34	.974	34	2.566	--	3.540	--

[1]Based on labor costs, including fringes, of $6.43 per hour as reported by firms cooperating in study.
[2]Includes depreciation, interest, equipment, maintenance, and power. See appendix tables 16, 20, and 21.
[3]See table 1.

TABLE 3.--Labor requirements and labor and equipment costs for 9 methods of shipping frozen foods in food warehouses

Method	Labor requirement		Labor cost[1]		Equipment cost[2]		Total costs	
	Man-minute per case	% higher than lowest method	Cents per case	% higher than lowest method	Cents per case	% higher than lowest method	Cents per case	% higher than lowest method
Conveyor-manual sorting:								
Selecting[3]	0.270	--	2.835	--	1.254	62	4.089	--
Loading	.021	24	.225	24	.022	--	.247	12
Total	.291	--	3.060	--	1.276	58	4.336	--
Conveyor-automatic sorting:								
Selecting[3]	.402	49	4.221	49	4.833	526	9.054	121
Loading (hand-stacked)	.186	994	1.990	993	--	--	1.990	801
Total	.588	102	6.211	103	4.833	497	11.044	155
Conveyor-single store:								
Selecting[3]	.336	24	3.528	24	.841	9	4.369	7
Loading (hand-stacked)	.120	606	1.284	606	--	--	1.284	481
Total	.456	57	4.812	56	.841	4	5.653	30
Carts and tuggers:								
Selecting[3]	.450	67	4.725	67	1.532	98	6.257	53
Loading	[4].021	24	.225	24	.022	--	.247	12
Total	.471	62	4.950	62	1.554	92	6.504	50
Pallets and double pallet jack:								
Selecting[3]	.342	27	3.591	27	.772	--	4.363	7
Loading	.017	--	.182	--	.038	73	.220	--
Total	.359	23	3.773	23	.810	--	4.584	6
Multilevel-pallets:								
Selecting[3]	.294	9	3.087	9	1.718	122	4.805	18
Loading	.017	--	.182	--	.038	73	.220	--
Total	.311	7	3.269	7	1.756	114	5.025	16
Insulated carts and tuggers:								
Selecting[3]	.606	124	6.363	124	7.023	810	13.386	227
Loading	.083	388	.888	388	.169	688	1.057	378
Total	.689	137	7.251	137	7.192	788	14.443	233
Insulated containers-predetermined guide path:								
Selecting[3]	.486	80	5.103	80	4.685	507	9.788	139
Loading	.055	224	.589	224	.125	468	.714	223
Total	.541	86	5.692	86	4.810	494	10.502	142
Insulated containers-single pallet:								
Selecting[3]	.516	91	5.418	91	3.566	361	8.984	120
Loading	.055	224	.589	224	.125	468	.714	223
Total	.571	96	6.007	96	3.691	356	9.698	124

[1]Based on labor costs, including fringes, of $6.30 per hour for order selectors and $6.43 per hour for loaders as reported by firms cooperating in study.

[2]Includes depreciation, interest, maintenance, and power. See appendix tables 17, 18, 20, and 21.

[3]Based on order sizes of between 100 and 200 cases.

[4]Time is for collapsible carts. Add 0.004 man-minute to obtain time for loading with rigid carts.

Table 4.--Labor requirements and labor and equipment costs for 4 methods of unloading frozen foods at retail stores

Method	Labor requirement		Labor[1]	Equipment[2]	Total costs	
	Man-minute per case	% higher than lowest method	Cents per case	Cents per case	Cents per case	% higher than lowest method
			Allocated to delivery			
Conveyor	0.090	137	0.963	--	0.963	137
Dock:						
Carts[3]	.038	--	.407	--	.407	--
Pallets	.054	42	.578	--	.578	42
Insulated carts	.108	184	1.156	--	1.156	184
Insulated containers	.058	53	.621	--	.621	53
Store lift:						
Carts[3]	.054	42	.578	--	.578	42
Pallets	.064	68	.685	--	.685	68
Insulated carts	.136	258	1.455	--	1.455	258
Insulated containers	.111	192	1.188	--	1.188	192
Truck lift:						
Carts[3]	.046	21	.492	.364	.856	110
Pallets	.059	55	.631	.365	.996	145
Insulated carts	.122	221	1.305	.370	1.675	312
Insulated containers	.098	158	1.049	.368	1.417	248
			Allocated to retail receiving			
Conveyor	.090	137	.945	.127	1.072	136
Dock:						
Carts[3]	.038	--	.404	.051	.455	--
Pallets	.054	42	.568	.051	.619	36
Insulated carts	.108	184	1.134	.051	1.185	160
Insulated containers	.058	53	.609	.051	.660	45
Store lift:						
Carts[3]	.054	42	.568	1.575	2.143	371
Pallets	.064	68	.672	1.619	2.291	404
Insulated carts	.136	258	1.428	1.605	3.033	567
Insulated containers	.111	192	1.166	1.637	2.803	516
Truck lift:						
Carts[3]	.046	21	.483	--	.483	6
Pallets	.059	55	.620	--	.620	36
Insulated carts	.122	221	1.281	--	1.281	182
Insulated containers	.098	158	1.029	--	1.029	126
			Totals			
Conveyor	.180	137	1.908	.127	2.035	136
Dock:						
Carts[3]	.076	--	.811	.051	.862	--
Pallets	.108	42	1.146	.051	1.197	39
Insulated carts	.216	184	2.290	.051	2.341	172
Insulated containers	.116	53	1.230	.051	1.281	49
Store lift:						
Carts[3]	.108	42	1.146	1.575	2.721	216
Pallets	.128	68	1.357	1.619	2.976	245
Insulated carts	.272	258	2.883	1.605	4.488	421
Insulated containers	.222	192	2.354	1.637	3.991	363
Truck lift:						
Carts[3]	.092	21	.975	.364	1.339	55
Pallets	.118	55	1.251	.365	1.616	88
Insulated carts	.244	221	2.586	.370	2.956	243
Insulated containers	.196	158	2.078	.368	2.446	184

[1]Based on labor costs, including fringes, of $6.43 per hour for delivery truck driver and $6.30 per hour for retail-receiving personnel, as reported by firms cooperating in study.

[2]Includes depreciation, interest, maintenance, and power. See appendix tables 18, 20, and 21.

[3]Data shown are for folding carts; add 0.24 man-minute to obtain time for rigid carts; add 0.147 cent for delivery and 0.147 cent for retail receiving to obtain costs for rigid carts.

TABLE 5.--Labor requirements and labor and equipment costs for 3 methods of transferring frozen foods from retail store receiving to sales area

Method	Labor requirement		Labor[1]	Equipment[2]	Total costs	
	Man-minute per case	% higher than lowest method	Cents per case	Cents per case	Cents per case	% higher than lowest method
Sort from unit onto stock cart:						
Carts	0.145	--	1.522	0.071	1.593	--
Pallets	.145	--	1.522	.071	1.593	--
Insulated carts	.154	6	1.617	.071	1.688	6
Insulated containers	.154	6	1.617	.071	1.688	6
Sort from unit onto sales floor:						
Carts	.282	95	2.961	--	2.961	86
Pallets	.253	75	2.661	--	2.661	67
Insulated carts	.300	107	3.150	--	3.150	98
Insulated containers	.300	107	3.150	--	3.150	98
Stock from unit:						
Carts	.173	19	1.817	--	1.817	14
Pallets	.173	19	1.817	--	1.817	14
Insulated carts	.184	27	1.932	--	1.932	21
Insulated containers	.184	27	1.932	--	1.932	21

[1]Based on labor costs, including fringes, of $6.30 per hour as reported by firms cooperating in study.
[2]Equipment costs not shown have already been charged to the warehouse.

TABLE 6.--Labor requirements and labor and equipment costs for 4 methods of price marking frozen food packages in retail stores[1]

Method	Labor requirement		Labor[2]	Equipment[3]	Total costs	
	Man-minute per case	% higher than lowest method	Cents per case	Cents per case	Cents per case	% higher than lowest method
Band stamp	0.993	18	10.427	0.176	10.603	16
Labels	.892	6	9.366	.342	9.708	6
Stick stamp	.844	--	8.862	.263	9.125	--
Self-inking stick stamp	.844	--	8.862	.304	9.166	(4)

[1]Assumed that cases were positioned and opened for price marking.
[2]Based on labor costs, including fringes, of $6.30 per hour as reported by firms cooperating in study.
[3]Includes cost of supplies. See appendix table 19.
[4]Less than 0.5 percent.

TABLE 7.--Labor requirements and costs for stocking 3 types of frozen food display cases[1]

Display case	Labor requirement		Labor cost[2]	
	Man-minute per case	% higher than lowest method	Cents per case	% higher than lowest method
Single deck[3]--------	0.606	--	6.363	--
Multilevel upright--	.712	18	7.476	18
Reach-in----------	.685	13	7.193	13

[1]Requirements and costs are for stocking products that had been price marked in the backroom and transferred to the sales area.

[2]Based on labor costs, including fringes, of $6.30 per hour as reported by firms cooperating in study.

[3]Single deck frozen food display cases are often called "coffin" type display cases.

TABLE 8.--Labor requirements and labor and equipment costs for the warehouse and delivery parts

Requirement and cost item	System A[1]		System B[1]		System C[1]		System D[1]	
	Requirement Man-minutes per case	Costs Cents per case	Requirement Man-minutes per case	Costs Cents per case	Requirement Man-minutes per case	Costs Cents per case	Requirement Man-minutes per case	Costs Cents per case
Receiving:								
Labor	0.053	0.566	0.058	0.621	0.058	0.621	0.058	0.621
Equipment	--	3.960	--	2.021	--	2.021	--	2.021
Total	.053	4.526	.058	2.642	.058	2.642	.058	2.642
Replenishing[2]:								
Labor	.015	.160	.033	.353	.033	.354	.033	.353
Equipment	--	1.360	--	.545	--	.545	--	.545
Total	.015	1.520	.033	.898	.033	.898	.033	.898
Shipping[3]:								
Labor	.588	6.211	.456	4.812	.291	3.060	.471	4.950
Equipment	--	4.833	--	.841	--	1.276	--	1.554
Total	.588	11.044	.456	5.653	.291	4.336	.471	6.504
Total warehouse:								
Labor	.656	6.937	.547	5.786	.382	4.034	.562	5.924
Equipment	--	10.153	--	3.407	--	3.842	--	4.120
Total	.656	17.090	.547	9.193	.382	7.876	.562	10.044
Delivery[4]:								
Conveyor unloading at retail store:								
Labor	.295	2.194	.295	2.194	--	--	--	--
Equipment	--	2.827	--	2.827	--	--	--	--
Total	.295	5.021	.295	5.021	--	--	--	--
Dock unloading at retail store:								
Labor	--	--	--	--	.338	3.617	.338	3.617
Equipment	--	--	--	--	--	4.147	--	4.147
Total	--	--	--	--	.338	7.764	.338	7.764
Store lift unloading at retail store:								
Labor	--	--	--	--	.354	3.788	.354	3.788
Equipment	--	--	--	--	--	4.147	--	4.147
Total	--	--	--	--	.354	7.935	.354	7.935
Truck lift unloading at retail store:								
Labor	--	--	--	--	.346	3.702	.346	3.702
Equipment	--	--	--	--	--	4.147	--	4.147
Total	--	--	--	--	.346	7.849	.346	7.849

[1]Systems are as follows:

A--Storage-retrieval machines; conveyor selection with automatic sorting, hand-stack loading; conveyor unloading.
B--Forklift trucks; conveyor selection of single store orders; hand-stack loading, conveyor unloading.
C--Forklift trucks; conveyor selection with manual sorting onto carts; dock, store lift, truck lift unloading.
D--Forklift trucks; carts and tuggers; dock, store lift, truck lift unloading.
E--Powered pallet jacks; forklift trucks; pallets and pallet jacks; dock, store lift, truck lift unloading.
F--Forklift trucks; multilevel order selection onto pallets; dock, store lift, truck lift unloading.
G--Forklift trucks; insulated carts and tuggers; dock, store lift, truck lift unloading.
H--Forklift trucks; insulated containers on predetermined guide path; dock, store lift, truck lift unloading.
I--Forklift trucks; insulated containers; dock, store lift, truck lift unloading.

[2]Assumed no replenishing was required where multilevel selection was used.

of 9 selected systems for handling frozen foods from warehouse receiving to retail store display

System E[1]		System F[1]		System G[1]		System H[1]		System I[1]	
Requirement Man-minutes per case	Costs Cents per case	Requirement Man-minutes per case	Costs Cents per case	Requirement Man-minutes per case	Costs Cents per case	Requirement Man-minutes per case	Costs Cents per case	Requirement Man-minutes per case	Costs Cents per case
0.064	0.685	0.058	0.621	0.058	0.621	0.058	0.621	0.058	0.621
--	2.048	--	2.021	--	2.021	--	2.021	--	2.021
.064	2.733	.058	2.642	.058	2.642	.058	2.642	.058	2.642
.033	.353	--	--	.033	.353	.033	.353	.033	.353
--	.545	--	--	--	.545	--	.545	--	.545
.033	.898	--	--	.033	.898	.033	.898	.033	.898
.359	3.773	.311	3.269	.689	7.251	.541	5.692	.571	6.007
--	.810	--	1.756	--	7.192	--	4.810	--	3.691
.359	4.584	.311	5.025	.689	14.443	.541	10.502	.571	9.698
.456	4.811	.369	3.890	.780	8.225	.632	6.666	.662	6.981
--	3.403	--	3.777	--	9.758	--	7.376	--	6.257
.456	8.214	.369	7.667	.780	17.983	.632	14.042	.662	13.238
--	--	--	--	--	--	--	--	--	--
--	--	--	--	--	--	--	--	--	--
--	--	--	--	--	--	--	--	--	--
.304	3.253	.304	3.253	.108	1.156	.058	.621	.058	.621
--	3.546	--	3.546	--	--	--	--	--	--
.304	6.799	.304	6.799	.108	1.156	.058	.621	.058	.621
.314	3.360	.314	3.360	.136	1.455	.111	1.188	.111	1.188
--	3.546	--	3.546	--	--	--	--	--	--
.314	6.906	.314	6.906	.136	1.455	.111	1.188	.111	1.188
.309	3.306	.309	3.306	.122	1.305	.098	1.049	.098	1.049
--	3.546	--	3.546	--	--	--	--	--	--
.309	6.852	.309	6.852	.122	1.305	.098	1.049	.098	1.049

[3]Based on order sizes ranging from 100 to 200 cases.

[4]For purposes of comparison, it was assumed that for Systems A through F products were delivered in totally refrigerated trucks, and that for Systems G, H, and I products were delivered in nonrefrigerated trucks and were not charged transportation costs.

TABLE 9.--Labor requirements and labor and equipment costs for retail store part of 9 selected

Requirement and cost item	System A[1]		System B[1]		System C[1]		System D[1]	
	Requirement Man-minutes per case	Costs Cents per case	Requirement Man-minutes per case	Costs Cents per case	Requirement Man-minutes per case	Costs Cents per case	Requirement Man-minutes per case	Costs Cents per case
Receiving:								
Conveyor:								
Labor	0.090	0.945	0.090	0.945	--	--	--	--
Equipment	--	.127	--	.127	--	--	--	--
Total	.090	1.072	.090	1.072	--	--	--	--
Dock:								
Labor	--	--	--	--	.038	.404	.038	.404
Equipment	--	--	--	--	--	.051	--	.051
Total	--	--	--	--	.038	.455	.038	.455
Store lift:								
Labor	--	--	--	--	.054	.568	.054	.568
Equipment	--	--	--	--	--	1.575	--	1.575
Total	--	--	--	--	.054	2.143	.054	2.143
Truck lift:								
Labor	--	--	--	--	.046	.483	.046	.483
Equipment	--	--	--	--	--	--	--	--
Total	--	--	--	--	.046	.483	.046	.483
Transfer to sales area[2]:								
Labor	--	--	--	--	.145	1.522	.145	1.522
Equipment	--	--	--	--	--	.071	--	.071
Total	--	--	--	--	.145	1.593	.145	1.593
Price marking[3]:								
Labor	.844	8.862	.844	8.862	.844	8.862	.844	8.862
Equipment	--	.263	--	.263	--	.263	--	.263
Total	.844	9.125	.844	9.125	.844	9.125	.844	9.125
Display case stocking[4]:								
Labor	.606	6.363	.606	6.363	.606	6.363	.606	6.363
Equipment	--	--	--	--	--	--	--	--
Total	.606	6.363	.606	6.363	.606	6.363	.606	6.363
Total retail store:								
Conveyor unloading:								
Labor	1.540	16.170	1.540	16.170	--	--	--	--
Equipment	--	.390	--	.390	--	--	--	--
Total	1.540	16.560	1.540	16.560	--	--	--	--
Dock unloading:								
Labor	--	--	--	--	1.633	17.151	1.633	17.151
Equipment	--	--	--	--	--	.385	--	.385
Total	--	--	--	--	1.633	17.536	1.633	17.536
Store lift unloading:								
Labor	--	--	--	--	1.649	17.315	1.649	17.315
Equipment	--	--	--	--	--	1.909	--	1.909
Total	--	--	--	--	1.649	19.224	1.649	19.224
Truck lift unloading:								
Labor	--	--	--	--	1.641	17.230	1.641	17.230
Equipment	--	--	--	--	--	.334	--	.334
Total	--	--	--	--	1.641	17.564	1.641	17.564

[1]See footnote 1, table 8 for description of systems.
[2]To simplify analysis, assumed products were sorted onto stock carts and transferred to sales area.
[3]To simplify analysis, assumed stick stamps were used for price marking.
[4]To simplify analysis, assumed single deck display cases were used.

systems for handling frozen foods from warehouse receiving to retail store display

System E[1]		System F[1]		System G[1]		System H[1]		System I[1]	
Requirement	Costs	Requirement	Costs	Requirement	Costs	Requirement	Costs	Requirement	Costs
Man-minutes per case	Cents per case	Man-minutes per case	Cents per case	Man-minutes per case	Cents per case	Man-minutes per case	Cents per case	Man-minutes per case	Cents per case
--	--	--	--	--	--	--	--	--	--
--	--	--	--	--	--	--	--	--	--
--	--	--	--	--	--	--	--	--	--
.054	.568	.054	.672	.108	1.134	.058	.609	.058	.609
--	.051	--	1.619	--	.054	--	.051	--	.051
.054	.619	.054	2.291	.108	1.188	.058	.660	.058	.660
.064	.672	.064	.672	.136	1.428	.111	1.166	.111	1.166
--	1.619	--	1.619	--	1.605	--	1.637	--	1.637
.064	2.291	.064	2.291	.136	3.033	.111	2.803	.111	2.803
.059	.620	.059	.620	.122	1.281	.098	1.029	.098	1.029
--	.008	--	.008	--	.013	--	.011	--	.011
.059	.628	.059	.628	.122	1.294	.098	1.040	.098	1.040
.145	1.522	.145	1.522	.154	1.617	.154	1.617	.154	1.617
--	.071	--	.071	--	.071	--	.071	--	.071
.145	1.593	.145	1.593	.154	1.688	.154	1.688	.154	1.688
.844	8.862	.844	8.862	.844	8.862	.844	8.862	.844	8.862
--	.263	--	.263	--	.263	--	.263	--	.263
.844	9.125	.844	9.125	.844	9.125	.844	9.125	.844	9.125
.606	6.363	.606	6.363	.606	6.363	.606	6.363	.606	6.363
--	--	--	--	--	--	--	--	--	--
.606	6.363	.606	6.363	.606	6.363	.606	6.363	.606	6.363
--	--	--	--	--	--	--	--	--	--
--	--	--	--	--	--	--	--	--	--
--	--	--	--	--	--	--	--	--	--
1.649	17.315	1.649	17.315	1.712	17.976	1.662	17.451	1.662	17.451
--	.385	--	.385	--	.385	--	.392	--	.392
1.649	17.700	1.649	17.700	1.712	18.361	1.662	17.843	1.662	17.843
1.659	17.419	1.659	17.419	1.740	18.270	1.715	18.008	1.715	18.008
--	1.953	--	1.953	--	1.939	--	1.971	--	1.971
1.659	19.372	1.659	19.372	1.740	20.209	1.715	19.979	1.715	19.979
1.654	17.367	1.654	17.367	1.726	18.123	1.702	17.871	1.702	17.871
--	.342	--	.342	--	.347	--	.345	--	.345
1.654	17.709	1.654	17.709	1.726	18.470	1.702	18.216	1.702	18.216

TABLE 10.--Total labor requirements and total labor and equipment costs for 9 selected

Requirement and cost item	System A[2] Requirement Man-minutes per case	System A[2] Costs Cents per case	System B[2] Requirement Man-minutes per case	System B[2] Costs Cents per case	System C[2] Requirement Man-minutes per case	System C[2] Costs Cents per case	System D[2] Requirement Man-minutes per case	System D[2] Costs Cents per case
Total warehouse:								
Labor	0.656	6.937	0.547	5.786	0.382	4.034	0.562	5.924
Equipment	--	10.153	--	3.407	--	3.842	--	4.120
Total	.656	17.090	.547	9.193	.382	7.876	.562	10.044
Total delivery:								
Conveyor unloading at retail store:								
Labor	.295	2.194	.295	2.194	--	--	--	--
Equipment	--	2.827	--	2.827	--	--	--	--
Total	.295	5.021	.295	5.021	--	--	--	--
Dock unloading at retail store:								
Labor	--	--	--	--	.338	3.617	.338	3.617
Equipment	--	--	--	--	--	4.147	--	4.147
Total	--	--	--	--	.338	7.764	.338	7.764
Store lift unloading at retail store:								
Labor	--	--	--	--	.354	3.788	.354	3.788
Equipment	--	--	--	--	--	4.147	--	4.147
Total	--	--	--	--	.354	7.935	.354	7.935
Truck lift unloading at retail store:								
Labor	--	--	--	--	.346	3.702	.346	3.702
Equipment	--	--	--	--	--	4.147	--	4.147
Total	--	--	--	--	.346	7.849	.346	7.849
Total retail store:								
Conveyor unloading:								
Labor	1.540	16.170	1.540	16.170	--	--	--	--
Equipment	--	.390	--	.390	--	--	--	--
Total	1.540	16.560	1.540	16.560	--	--	--	--
Dock unloading:								
Labor	--	--	--	--	1.633	17.151	1.633	17.151
Equipment	--	--	--	--	--	.385	--	.385
Total	--	--	--	--	1.633	17.536	1.633	17.536
Store lift unloading:								
Labor	--	--	--	--	1.649	17.315	1.649	17.315
Equipment	--	--	--	--	--	1.909	--	1.909
Total	--	--	--	--	1.649	19.224	1.649	19.224
Truck lift unloading:								
Labor	--	--	--	--	1.641	17.230	1.641	17.230
Equipment	--	--	--	--	--	.334	--	.334
Total	--	--	--	--	1.641	17.564	1.641	17.564
Grand totals:								
Conveyor unloading:								
Labor	2.491	25.301	2.382	24.150	--	--	--	--
Equipment	--	13.370	--	6.624	--	--	--	--
Total	2.491	38.671	2.382	30.774	--	--	--	--
Dock unloading:								
Labor	--	--	--	--	2.353	24.802	2.533	26.692
Equipment	--	--	--	--	--	8.374	--	8.652
Total	--	--	--	--	2.353	33.176	2.533	35.344
Store lift unloading:								
Labor	--	--	--	--	2.385	25.137	2.565	27.027
Equipment	--	--	--	--	--	9.898	--	10.176
Total	--	--	--	--	2.385	35.035	2.565	37.202
Truck lift unloading:								
Labor	--	--	--	--	2.369	24.966	2.549	26.856
Equipment	--	--	--	--	--	8.323	--	8.601
Total	--	--	--	--	2.369	33.289	2.549	35.457

[1]Totals shown are summations of totals in tables 8 and 9. For assumptions, see footnotes 2, 3, and 4 in tables 8 and 9.
[2]See footnote 1, table 8, for description of systems.

systems for handling frozen foods from warehouse receiving to retail store display[1]

System E[2]		System F[2]		System G[2]		System H[2]		System I[2]	
Requirement	Costs	Requirement	Costs	Requirement	Costs	Requirement	Costs	Requirement	Costs
Man-minutes per case	Cents per case	Man-minutes per case	Cents per case	Man-minutes per case	Cents per case	Man-minutes per case	Cents per case	Man-minutes per case	Cents per case
0.456	4.811	0.369	3.890	0.780	8.225	0.632	6.666	0.662	6.981
--	3.403	--	3.777	--	9.758	--	7.376	--	6.257
.456	8.214	.369	7.667	.780	17.983	.632	14.042	.662	13.238
--	--	--	--	--	--	--	--	--	--
--	--	--	--	--	--	--	--	--	--
--	--	--	--	--	--	--	--	--	--
.304	3.253	.304	3.253	.108	1.156	.058	.621	.058	.621
--	3.546	--	3.546	--	--	--	--	--	--
.304	6.799	.304	6.799	.108	1.156	.058	.621	.058	.621
.314	3.360	.314	3.360	.136	1.455	.111	1.188	.111	1.188
--	3.546	--	3.546	--	--	--	--	--	--
.314	6.906	.314	6.906	.136	1.455	.111	1.188	.111	1.188
.309	3.306	.309	3.306	.122	1.305	.098	1.049	.098	1.049
--	3.546	--	3.546	--	--	--	--	--	--
.309	6.852	.309	6.852	.122	1.305	.098	1.049	.098	1.049
--	--	--	--	--	--	--	--	--	--
--	--	--	--	--	--	--	--	--	--
--	--	--	--	--	--	--	--	--	--
1.649	17.315	1.649	17.315	1.712	17.976	1.622	17.451	1.662	17.451
--	.385	--	.385	--	.385	--	.392	--	.392
1.649	17.700	1.649	17.700	1.712	18.361	1.622	17.843	1.662	17.843
1.659	17.419	1.659	17.419	1.740	18.270	1.715	18.008	1.715	18.008
--	1.953	--	1.953	--	1.939	--	1.971	--	1.971
1.659	19.372	1.659	19.372	1.740	20.209	1.715	19.979	1.715	19.979
1.654	17.367	1.654	17.367	1.726	18.123	1.702	17.871	1.702	17.871
--	.342	--	.342	--	.347	--	.345	--	.345
1.654	17.709	1.654	17.709	1.726	18.470	1.702	18.216	1.702	18.216
--	--	--	--	--	--	--	--	--	--
--	--	--	--	--	--	--	--	--	--
--	--	--	--	--	--	--	--	--	--
2.409	25.379	2.322	24.458	2.600	27.357	2.352	24.738	2.382	25.053
--	7.334	--	7.708	--	10.143	--	7.768	--	6.649
2.409	32.713	2.322	32.166	2.600	37.500	2.352	32.506	2.382	31.702
2.429	25.590	2.342	24.669	2.656	27.950	2.458	25.862	2.488	26.177
--	8.902	--	9.276	--	11.697	--	9.347	--	8.228
2.429	34.492	2.342	33.945	2.656	39.647	2.458	35.209	2.488	34.405
2.419	25.484	2.332	24.563	2.628	27.653	2.432	25.586	2.462	25.901
--	7.291	--	7.665	--	10.105	--	7.721	--	6.602
2.419	32.775	2.332	32.228	2.628	37.758	2.432	33.307	2.462	32.503

TABLE 11.--Ranking (lowest to highest) of total per-case costs and requirements of 9 selected systems for handling frozen foods from warehouse receiving to retail store display[1]

Rank	Labor and equipment costs					Labor requirement				
	System[2]	Retail unloading method	Cost	Cost difference	Percent difference	System[2]	Retail unloading method	Time	Time difference	Percent difference
			Cents per case	Cents per case				Man-minutes per case	Man-minutes per case	
1------	B	Conveyor	30.774	--	--	F	Dock	2.322	--	--
2------	I	Dock	31.702	0.928	3	F	Truck lift	2.332	0.010	(3)
3------	F	Dock	32.166	1.392	5	F	Store lift	2.342	.020	1
4------	F	Truck lift	32.228	1.454	5	H	Dock	2.352	.030	1
5------	I	Truck lift	32.503	1.729	6	C	Dock	2.353	.031	1
6------	H	Dock	32.506	1.732	6	C	Truck lift	2.369	.047	2
7------	E	Dock	32.713	1.939	6	I	Dock	2.382	.060	3
8------	E	Truck lift	32.775	2.001	7	B	Conveyor	2.382	.060	3
9------	C	Dock	33.176	2.402	8	C	Store lift	2.385	.063	3
10------	C	Truck lift	33.289	2.515	8	E	Dock	2.409	.087	3
11------	H	Truck lift	33.307	2.533	8	E	Truck lift	2.419	.097	4
12------	F	Store lift	33.945	3.171	10	E	Store lift	2.429	.107	5
13------	I	Store lift	34.405	3.631	12	H	Truck lift	2.432	.110	5
14------	E	Store lift	34.492	3.718	12	H	Store lift	2.458	.136	6
15------	C	Store lift	35.035	4.261	14	I	Truck lift	2.462	.140	6
16------	H	Store lift	35.209	4.435	14	I	Store lift	2.488	.166	7
17------	D	Dock	35.344	4.570	15	A	Conveyor	2.491	.169	7
18------	D	Truck lift	35.475	4.683	15	D	Dock	2.533	.211	9
19------	D	Store lift	37.203	6.429	21	D	Truck lift	2.549	.227	9
20------	G	Dock	37.500	6.672	22	D	Store lift	2.565	.243	11
21------	G	Truck lift	37.758	6.984	23	G	Dock	2.600	.278	12
22------	A	Conveyor	38.671	7.897	26	G	Truck lift	2.628	.306	13
23------	G	Store lift	39.647	8.873	29	G	Store lift	2.656	.334	14

[1]Costs and requirements are taken from table 10. For assumptions, see footnotes 2, 3, and 4 in tables 8 and 9.
[2]See footnote 1, table 8, for description of systems.
[3]Less than 0.5 percent.

TABLE 12.--Ranking (lowest to highest) of average per-case costs and requirements for combinations of systems and retail unloading methods for handling frozen foods from warehouse receiving to retail store display[1]

Rank	System[2]	Labor and equipment costs Cents per case	System[2]	Labor requirement Man-minutes per case
1-----	[3]B	30.774	F	2.332
2-----	F	32.780	C	2.369
3-----	I	32.870	[3]B	2.382
4-----	E	33.327	H	2.414
5-----	H	33.675	E	2.419
6-----	C	33.833	I	2.444
7-----	D	36.001	[3]A	2.491
8-----	G	38.302	D	2.549
9-----	[3]A	38.671	G	2.628

[1]Data shown are an average of data for each system shown in table 11. For assumptions, see footnotes 2, 3, and 4 in tables 8 and 9.
[2]See footnote 1, table 8 for description of systems.
[3]Systems A and B are conveyor unloading only.

TABLE 13.--Ranking (lowest to highest) of adjusted average costs of 9 selected systems for handling frozen foods from warehouse receiving to retail store display[1]

Rank	System[2, 3]	Costs Cents per case
1-------	C (6)	26.605
2-------	F (2)	26.787
3-------	E (4)	27.334
4-------	D (7)	28.773
5-------	B (1)	30.774
6-------	I (3)	32.870
7-------	H (5)	33.675
8-------	G (8)	38.302
9-------	A (9)	38.671

[1]Based on costs shown in table 12 with adjustments amounting to -7.228 cents and -5.993 cents per case, respectively, for systems using carts (Systems C and D) and for systems using pallets (Systems E and F). For assumptions, see footnotes 2, 3, and 4 in tables 8 and 9.
[2]See footnote 1, table 8 for description of systems.
[3]Numbers in parentheses refer to ranking of firm in table 12.

TABLE 14.--Ranking (lowest to highest) of average per-case handling and warehouse facility rental costs of 9 selected systems for handling frozen foods from warehouse receiving to retail store display[1]

Rank	System[2, 3]	Handling cost Cents per case	Facility rental cost Cents per case	Total cost Cents per case
1-----	C (6)	33.833	3.948	37.781
2-----	I (3)	32.870	6.007	38.877
3-----	E (4)	33.327	5.575	38.902
4-----	B (1)	30.774	8.473	39.247
5-----	H (5)	33.675	6.007	39.682
6-----	D (7)	36.001	5.575	41.576
7-----	A (9)	38.671	3.305	41.976
8-----	F (2)	32.780	10.520	43.300
9-----	G (8)	38.302	5.634	43.936

[1]For assumptions, see footnotes 2, 3, and 4 in tables 8 and 9.
[2]See footnote 1, table 8, for description of systems.
[3]Numbers in parentheses refer to ranking of systems when only handling costs are considered (table 12).

TABLE 15.--Actual and alternate construction dimensions and costs for frozen food warehouses for each system[1]

Item	System A[2]		System B[2]		System C[2]		Systems D and E[2]		System F[2]		System G[2]		Systems H and I[2]	
	Actual	Alternate	Actual	Alternate	Actual	Alternate	Actual	Alternate	Actual	Alternate	Actual	Alternate	Actual	Alternate
Dimensions:														
Area (thousand sq ft)-	30	24	44	20	43	22	47	30	12	5	30	24	65	44
Measurement (feet)----	326x92	261x92	185x236	148x135	189x227	126x174	148x318	146x205	115x104	77x70	148x202	148x162	205x320	164x268
Clear height (feet)---	44	52	18	41	23	41	25	37	17	41	18	23	29	41
Costs (thousand dollars)[3]:														
Foundation----------	33	31	45	21	37	28	43	29	17	15	29	24	48	43
Slabs----------	43	35	63	37	41	35	48	43	17	15	31	24	68	63
Structural steel------	133	113	139	93	138	98	132	104	36	31	71	73	202	174
Miscellaneous iron----	14	10	14	9	14	9	13	10	3	2	7	7	20	17
Roofing----------	48	40	69	40	64	36	64	48	21	10	41	35	90	72
Exterior walls--------	170	178	71	105	75	117	104	128	39	58	59	65	132	174
Sprinklers[4]----------	**54	***60	°31	**59	*53	**91	*32	**54	*8	**20	°20	°17	*71	**81
Electrical----------	52	36	77	37	75	40	81	52	22	13	46	41	110	75
Heating----------	40	33	54	31	54	35	61	40	16	10	43	32	75	56
Roof drainage---------	8	8	8	8	7	8	8	8	3	2	5	3	12	10
Supervision----------	35	35	35	35	35	35	35	35	29	29	35	35	40	35
General expense-------	30	30	29	29	29	29	29	29	21	21	29	29	35	29
Freezer premium[5]:														
Wall----------	125	132	52	86	62	91	75	81	33	51	43	46	99	133
Cooling----------	190	161	254	151	254	152	289	190	76	33	161	153	370	301
Roof----------	76	61	104	58	100	58	105	75	33	20	75	56	152	104
Total cost (thousand dollars[6]----------	1,051	963	1,045	799	1,038	862	1,169	926	374	330	695	640	1,524	1,367
Cost per square foot (dollars)------	35.03	40.13	23.75	39.95	24.14	39.18	24.87	30.87	31.17	61.11	23.17	26.67	23.45	31.07
Cost per cubic foot (dollars)----------	.80	.77	1.32	.97	1.05	.96	1.00	.83	1.83	1.49	1.29	1.16	.81	.76
Annual rental (cents per case)[7]:														
Cost----------	3.305	3.029	8.473	6.405	3.948	3.279	5.575	4.416	10.520	9.282	5.634	5.188	6.007	5.388
Difference between actual and alternate-	.276		2.068		.669		1.159		1.238		.466		.619	

[1]Based on construction costs in Boston, Mass., area, February 1975.
[2]See footnote 1, table 8, for description of systems.
[3]Costs include engineering and other fees. Also, costs shown prior to "freezer premium" are those of a conventional warehouse.
[4]Sprinklers indicated as follows: ° = roof level only, * = roof level plus 1-level rack, ** = roof level plus 2-level rack, and *** = roof level plus 3-level rack.
[5]Premium for construction of building as a freezer.
[6]Total costs do not include such widely varying items as site preparation, site utilities, site improvements, secondary water systems, hose stations, smoke and heat vents, plumbing, interior walls, and finish.
[7]Annual rental costs based on 31 percent of construction costs ÷ volume handled as reported by the firms cooperating in study.

APPENDIX

TABLE 16.--Ownership costs of equipment for handling frozen foods from warehouse receiving to order selection

Equipment	Initial cost[1]	Estimated life	Annual cost[2]	Daily cost[3]	Hourly cost[4]	Cost per case	Factor used to convert cost to cost per case
	Dollars	Years	Dollars	Cents	Cents	Cents	
Receiving:							
Plywood sheets	6.00	5	1.50	--	--	0.577	10,000 sheets for 2,600,000 cases.
Forklift truck (dock only)[5]	9,000.00	5	2,250.00	865.48	108.75	.029	0.016 minute per case.
Dollies (plywood sheets)	80.00	5	20.00	7.69	.01	--	
Pallets	6.00	3	2.30	--	--	.885	10,000 pallets for 2,600,000 cases.
Powered pallet jack[5]	6,000.00	5	1,500.00	576.90	72.11	.026	0.022 minute per case or 2,727 cases per hour.
Transfer to storage area:							
Forklift truck[5]	12,000.00	5	3,000.00	1,153.80	144.22	.017	0.007 minute per case or 8,571 cases per hour.
Powered pallet jack[5]	6,000.00	5	1,500.00	576.90	72.11	.014	0.012 minute per case or 5,000 cases per hour.
Place into storage:							
Storage-retrieval machine	50,000.00	5	12,500.00	4,807.70	[6]300.48	.185	0.037 minute per case or 1,622 cases per hour.
Forklift truck[5]	12,000.00	5	3,000.00	1,153.80	[6] 72.11	.035	0.029 minute per case or 2,069 cases per hour.
Replenish selection:							
Storage-retrieval machine	--	--	--	--	[6]300.48	.075	0.015 minute per case or 4,000 cases per hour.
Forklift truck[5]	--	--	--	--	[6] 72.11	.040	0.033 minute per case or 1,818 cases per hour.
Racking:							
Storage-retrieval machine	[7]70	10	10.50	--	--	4.038	10,000 pallets for 2,600,000 cases.
Forklift operation	[7]25	10	3.75	--	--	1.442	10,000 pallets for 2,600,000 cases.

[1]1975 costs.
[2]Includes depreciation and 10 percent interest.
[3]260 days per year.
[4]If used for 2 shifts, costs were divided.
[5]Includes costs of battery and charger.
[6]Costs divided between "transfer to storage area" and "transfer to replenish selection."
[7]Per pallet.

TABLE 17.--Ownership costs of equipment for

Method and equipment	Initial cost[1]	Estimated life	Annual cost[2]	Daily cost[3]	Hourly cost[4]	Cost per case
	Dollars	Years	Dollars	Cents	Cents	Cents
Conveyor-automatic sort:						
Conveyor system	130,000	5	32,500.00	12,500.00	1,562.50	1.744
Automatic sorter	8,000	5	2,000.00	769.20	96.15	.107
Conveyor-single store	35,000	5	8,750.00	3,365.40	420.68	.393
Conveyor-manual sort:						
Conveyor system, carousel	60,000	5	15,000.00	5,769.20	721.15	.406
Carts	150	5	37.50	--	--	.578
Carts and tuggers:						
Carts	150	5	37.50	--	--	.578
Hitches	50	5	13.50	5.19	.65	.005
Tuggers	5,600	5	1,400.00	538.50	67.31	.506
Double pallet jack-pallets:						
Pallet jack	5,700	5	1,425.00	548.10	68.51	.392
Pallets	6	3	2.20	--	--	.024
Multilevel:						
Order selecting machine	12,500	5	3,125.00	1,201.90	150.24	.736
Power supply	5,028	5	1,257.00	483.50	60.44	.148
Aisle guides	4,356	5	1,089.00	418.80	52.35	.128
Pallets	6	3	2.20	--	--	.024
Insulated carts:						
Insulated carts	763	5	190.75	--	--	6.056
Hitches	50	5	13.50	5.19	.65	.007
Tuggers	3,000	5	750.00	288.50	36.06	.364
Insulated containers-predetermined guide path:						
Insulated containers	350	5	87.50	--	--	2.559
Hitches	25	5	6.75	--	--	.001
Tuggers and controls	15,500	5	3,875.00	1,490.40	186.30	1.515
Guide path	35,000	5	8,750.00	3,365.40	210.34	.122
Nonpowered pallet jack	300	5	75.00	--	--	.010
Insulated containers:						
Insulated containers	350	5	87.50	--	--	2.559
Powered pallet jacks	4,500	5	1,125.00	432.70	54.09	.466

[1]1975 costs.
[2]Includes depreciation and 10 percent interest.
[3]260 days per year.
[4]If used for 2 shifts, costs were divided.

Factor used to convert costs to cost per case
0.402 man-minute per case ÷ 6 men = 0.067 minute per case. Same as for conveyor system above.
0.336 man-minute per case ÷ 6 men = 0.056 minute per case.
0.270 man-minute per case ÷ 8 men = 0.034 minute per case. 90 trips per year x 72 cases per trip = 6,480 cases per cart per year.
Same as for carts above.
0.450 minute per case or 133 cases per hour.
0.342 minute per case or 175 cases per hour. 90 trips per year x 100 cases per trip = 9,000 cases per pallet per year.
0.294 minute per case or 204 cases per hour. 0.294 minute per case per machine ÷ 2 machines = 0.147 minute per machine and 408 cases per hour. See power supply above. See pallets under "double pallet jack-pallets" method.
90 trips per year x 35 cases per trip = 3,150 cases per cart per year. 0.606 minute per case or 99 cases per hour. Same as for hitches above.
90 trips per year x 38 cases per trip = 3,420 cases per container per year.
0.486 minute per case or 123 cases per hour. 0.486 minute per case per container ÷ 14 containers at 1 time = 0.035 minute per case.
90 trips per year x 38 cases per trip = 3,420 cases per container per year. 0.576 minute per case or 116 cases per hour.

TABLE 18.--Ownership costs of equipment for loading frozen foods onto

Method and equipment	Initial cost[1]	Estimated life	Annual cost[2]	Daily cost[3]	Hourly cost[4]	Cost per case
	Dollars	Years	Dollars	Cents	Cents	Cents
Loading						
Carts:						
Dock board	125	10	13.75	5.29	0.661	--
Load locking bar	350	5	87.50	--	--	0.022
Pallets:						
Powered pallet jack[5]	6,000	5	1,500.00	576.90	72.113	.020
Dock board	125	10	13.75	5.29	.661	--
Wrap	50	2	27.50	--	--	.034
Insulated carts:						
Dock board	125	10	13.75	5.29	.661	.001
Load locking bar	350	5	87.50	--	--	.168
Insulated containers:						
Powered pallet jack[5]	6,000	5	1,500.00	576.90	72.113	.066
Dock board	125	10	13.75	5.29	.661	.001
Unloading						
Dock:						
Dock board	125	10	13.75	--	--	.009
Nonpowered pallet jack[6]	300	5	66.00	--	--	.042
Store lift:						
Store lift[5]	11,000	5	2,420.00	--	--	1.551
Nonpowered pallet jack[6]	300	5	66.00	--	--	.042
Truck lift:						
Truck lift[5]	6,905	5	1,726.75	--	--	.360
Nonpowered pallet jack[6]	300	5	66.00	--	--	.042
Conveyor:						
Truck conveyor	400	5	100.00	--	--	.016
Store conveyor	400	5	100.00	--	--	.064

[1]1975 costs.
[2]Includes depreciation and 10 percent interest.
[3]260 days per year.
[4]If used for 2 shifts, costs were divided.
[5]Includes costs of battery and charger.
[6]For unloading pallets and insulated containers.

delivery vehicles at warehouses and unloading at retail store	
	Factor used to convert cost to cost per case
	0.023 minute per case or 2,608 cases per hour. 260 trips per year x 1,500 cases per trip = 390,000 cases per year.
	0.017 minute per case or 3,529 cases per hour. 0.017 minute per case or 3,529 cases per hour.
	0.083 minute per case or 723 cases per year. 260 trips per year x 200 cases per trip = 5,200 cases per year.
	0.055 minute per case or 1,091 cases per hour. 0.055 minute per case or 1,091 cases per hour.
	Assumed frozen food receiving averages 300 cases per week or about 10 percent of cases received.
	do
	do
	do
	260 trips x 1,800 cases per trip = 468,000 cases per year. Assumed frozen food receiving averages 300 cases per week or about 10 percent of cases received.
	260 trips x 2,200 cases per trip = 572,000 cases per trip. Assumed frozen food receiving averages 300 cases per week or about 10 percent of cases received.

TABLE 19.--Ownership and supply costs of equipment for price marking frozen foods in retail stores

Method and equipment	Initial cost[1]	Estimated life	Annual cost[2]	Cost per case	Factor used to convert cost to cost per case
	Dollars	Years	Dollars	Cents	
Band stamp:					
Stamp and holster-----	5.99	2	3.30	0.031	200 cases per week or 10,400 cases per year.
Ink----------	--	--	13.92	.145	----------
Labels:					
Label gun and holster-----	26.45	2	14.55	.140	200 cases per week or 10,400 cases per year.
Labels-------	52¢/1,000	--	--	.057	10 percent waste included.
Ink----------	--	--	13.92	.145	----------
Stick stamp:					
Stamps-------	27.00	3	9.90	.095	200 cases per week or 10,400 cases per year.
Base---------	6.65	3	2.44	.023	----------
Ink----------	--	--	13.92	.145	----------
Self-inking stick stamp:					
Stamps-------	27.00	3	9.90	.095	200 cases per week or 10,400 cases per year.
Base---------	18.05	3	6.62	.064	----------
Ink----------	--	--	13.92	.145	----------

[1]1975 costs.
[2]Includes depreciation and 10 percent interest.

TABLE 20.--Maintenance costs of equipment for handling frozen foods from warehouse receiving to retail store display

Equipment	Annual cost[1]	Daily cost[2]	Hourly cost[3]	Cost per case	Factor used to convert cost to cost per case
	Dollars	Cents	Cents	Cents	
Warehouse					
Receiving:					
Storage-retrieval operation:					
Forklift truck (dock only)[4]	1,800	692.30	86.538	0.023	0.016 minute per case or 3,750 cases per hour.
Nonstorage-retrieval operations:					
Forklift truck (dock only)[4]	1,800	692.30	86.538	.033	0.023 minute per case or 2,609 cases per hour.
Powered pallet jack[4]	1,200	461.50	57.688	.021	0.022 minute per case or 2,727 cases per hour.
Transfer to storage:					
Forklift truck[4]	2,400	923.10	115.388	.013	0.007 minute per case or 8,571 cases per hour.
Powered pallet jack[4]	1,200	461.50	57.688	.012	0.012 minute per case or 5,000 cases per hour.
Place into storage:					
Storage-retrieval machine	5,000	1,923.08	120.193	.104	(1/4 man + parts) x 0.067 minute per case.
Forklift truck[4]	2,880	1,107.69	69.231	.072	0.062 minute per case or 968 cases per hour.
Order selecting:					
Conveyor-automatic sort:					
Conveyor system	10,000	3,846.15	480.760	.537	(1/2 man + parts) x 0.067 minute per case.
Conveyor-single store:					
Conveyor system	5,000	1,923.08	240.380	.224	0.056 minute per case or 1,071 cases per hour.
Conveyor-manual sort:					
Conveyor system	5,000	1,923.08	240.380	.135	0.045 minute per case or 1,333 cases per hour.
Carts and tuggers:					
Tuggers[4]	1,120	430.77	53.846	.404	0.450 minute per case or 133 cases per hour.
Double pallet jack:					
Double pallet jack[4]	1,140	438.46	54.808	.312	0.342 minute per case or 175 cases per hour.
Multilevel:					
Order selecting machine[4]	2,500	961.54	120.190	.589	0.294 minute per case or 204 cases per hour
Insulated carts:					
Tuggers[4]	1,120	430.77	53.846	.544	0.606 minute per case or 99 cases per hour.
Insulated containers:					
Tuggers[4]	1,120	430.77	53.846	.436	0.486 minute per case or 123 cases per hour.
Powered pallet jack[4]	1,200	461.50	57.688	.496	0.516 minute per case or 116 cases per hour.
Truck loading:					
Powered pallet jack (pallets)[4]	1,200	461.50	57.688	.016	0.017 minute per case or 3,529 cases per hour.
Powered pallet jack (containers)[4]	1,200	461.50	57.688	.053	0.055 minute per case or 1,091 cases per hour.
Retail store					
Unloading:					
Store lift when used with:					
Carts	500	192.31	24.040	.024	0.061 minute per case or 984 cases per hour.
Pallets				.026	0.064 minute per case or 938 cases per hour.
Insulated carts				.054	0.136 minute per case or 441 cases per hour.
Insulated containers				.044	0.111 minute per case or 541 cases per hour.
Truck lift when used with:					
Carts	100	38.46	4.808	.004	0.053 minute per case or 1,132 cases per hour.
Pallets				.005	0.057 minute per case or 1,052 cases per hour.
Insulated carts				.010	0.122 minute per case or 492 cases per hour.
Insulated containers				.008	0.098 minute per case or 612 cases per hour.

[1] Costs based on typical maintenance contract rates.
[2] Based on 260 days per year.
[3] If used for 2 shifts, costs were divided.
[4] Includes costs of battery and charger.

TABLE 21.--Power and materials costs of equipment for handling frozen foods from warehouse receiving to retail store display

Equipment	Annual cost[1]	Daily cost[2]	Hourly cost[3]	Cost per case	Factor used to convert cost to cost per case
	Dollars	Cents	Cents	Cents	
Warehouse					
Receiving:					
Storage-retrieval operation:					
Forklift truck (dock only)	250	96.15	12.019	0.003	0.016 minute per case or 3,750 cases per hour.
Nonstorage-retrieval operation:					
Forklift truck (dock only)	250	96.15	12.019	.005	0.023 minute per case or 2,609 cases per hour.
Powered pallet jack	109	41.92	5.240	.002	0.022 minute per case or 2,727 cases per hour.
Transfer to storage:					
Forklift truck	250	96.15	12.019	.001	0.007 minute per case or 8,571 cases per hour.
Powered pallet jack	109	41.92	5.240	.001	0.012 minute per case or 5,000 cases per hour.
Place into storage:					
Storage-retrieval machine	13,750	5,288.46	330.529	.286	0.052 minute per case or 1,154 cases per hour.
Forklift truck	250	96.15	12.019	.012	0.062 minute per case or 968 cases per hour.
Order selecting:					
Conveyor-automatic sort	41,250	15,865.40	1,983.175	[4] .271 [5] 1.944	0.067 minute per case or 896 cases per hour.
Conveyor-single store	5,000	1,923.08	240.380	.224	0.056 minute per case or 1,071 cases per hour.
Conveyor-manual sort	5,000	1,923.08	240.380	.135	0.045 minute per case or 1,333 cases per hour.
Carts and tuggers	109	41.92	5.240	.039	0.450 minute per case or 133 cases per hour.
Double pallet jack and pallets	160	61.45	7.692	.044	0.342 minute per case or 175 cases per hour.
Multilevel	250	96.15	12.019	[6] .059 [7] .034	0.294 minute per case or 204 cases per hour.
Insulated carts	109	41.92	5.240	.052	0.606 minute per case or 99 cases per hour.
Insulated container (guide path)	109	41.92	5.240	.042	0.486 minute per case or 123 cases per hour.
Insulated container	109	41.92	5.240	.045	0.516 minute per case or 116 cases per hour.
Truck loading:					
Powered pallet jack (pallets)	109	41.92	5.240	.001	0.017 minute per case or 3,529 cases per hour.
Powered pallet jack (containers)	109	41.92	5.240	.005	0.055 minute per case or 1,091 cases per hour.
Retail store					
Unloading:					
Store lift	negligible				
Truck lift	negligible				

[1] Based on costs reported by users and manufacturers.
[2] 260 days per year.
[3] If used for 2 shifts, costs were divided.
[4] Labels.
[5] Power.
[6] Machine.
[7] Heater

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